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THE RELATIONSHIP BETWEEN PLANNING AND SIMULTANEOUS AND SUCCESSIVE SYNTHESIS

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research for acceptance, a thesis entitled "The Relationship Between Planning and Simultaneous and Successive Synthesis" submitted by Adrian Frederick Ashman in partial fulfilment of the requirements for the degree of Doctor of Philosophy.

ABSTRACT

The present study extended the information integration model proposed by Das, Kirby and Jarman (1975) by discovering the planning factor and describing its relationship with simultaneous and successive synthesis. The primary purpose of the investigation was to answer two questions. The first of these dealt with delineation of a planning dimension which was independent of simultaneous and successive processing, and the second examined the pattern of similarities and differences which existed between a normal and a mentally retarded group.

Based upon Luria's functional organization of the brain, it was hypothesized that tests capable of differentiating frontal, from non-frontal lobe damaged patients would exemplify the human planning process. A set of planning tests and marker tests drawn from the simultaneous-successive battery were administered to a sample of normal, Grade 8 students. Factor analytic and analysis of variance techniques were employed to demonstrate the independence of the coding and planning dimensions. A second study using two adult groups produced results similar to those obtained from the adolescent sample.

These studies furnished three significant contributions. First, the identification of a planning factor which had foundations in neuropsychology supported the theoretical paradigm of Das' information processing model. Second, earlier research has been mainly concerned with the stability of the coding dimensions in elementary school children. Since this research included adult samples, it demonstrated that the factor structure is consistent over a wider age range than previously revealed. Third, the results obtained from the adult

mentally retarded sample conformed to the previous findings which compared retarded and nonretarded groups, showing qualitative similarities but quantitative differences.

The major implications of this study are that future research should now be directed towards validating the model using brain damaged subjects, and also towards resolving the issue of interdependence between coding and planning.

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CHAPTER I

INTRODUCTION

Among the various human characteristics, perhaps worthy of greatest admiration is man's ability to think. Research and speculation began to emerge from the laboratories of the social sciences before the turn of the century, and appeared to take more specific direction from the establishment of a psychometric laboratory by Francis Galton in 1884.

The history of cognitive functions has followed two major courses: 1. the development of Binet's intelligence test established the prediction of academic performance as the fundamental precept of psychometricians; and 2. the quest for the nature of intelligence led correlational psychologists to develop uni-, or multi-dimensional structures of human abilities. In the mid-1900's, attention turned towards the construct of aptitudes/abilities and psychologists began to examine the cognitive processes which bring about certain kinds of competencies in intellectual activities. And so, a major research thrust today is away from the *product,* and towards a *process* approach to man's mentation.

While much consideration has been given to coding, storage and retrieval of information, minimal interest has been shown in a process which appears to be uniquely human. Hess (1967) referred to this as causal thinking; it may also be called planning.

Planning is not a new concept in the study of intellectual activities. Guilford and Lacey (1947), French (1951) and Adkins and Lyerly (1952) reported a planning factor among general reasoning abilities. Though not clearly definable, they assumed that planning probably reflected diverse approaches to problem-solving. Berger, Guilford and

Christensen (1967) identified four dimensions of planning (elaboration, originality, judgment and ideational fluency) though recently, Guilford (1969) relegated planning to a position parallel to decision-making, involving operations and products (two dimensions of his Structure of Intellect model).

Two cybernetic models have advanced a process approach to planning. The Miller, Galanter and Pribram (1960) TOTE (test-operate-test-exit) system is a simplistic model in which plans become operative if incongruity in the initial testing phase is encountered. When execution of a plan begins, program-oriented tasks are engaged to deal with data gathering and logging of the plan's sequence for reference. Depending upon feedback, plans may be revised, integrated or concatenated. Intelligent co-ordination of the planning activity, however, requires a mechanism to mediate execution, and this, presumably, is the TOTE system. In contrast, Anokhin's (1969) neurocybernetic concept of afferent synthesis accounts for thorough processing, comparison, and synthesis of all information needed by the organism to perform the most appropriate act. The neuro-physiological activity of afferent synthesis is analogous to the planning function, precedes decision-making, and is associated with electrocortical discharges originating in the frontal lobes.

The position adopted herein may be viewed as a theoretical midpoint between Miller *et al.* and Anokhin. Planning is defined as a cognitive process involving the organization of information into input or output sequences which may lead to goal attainment. This process is assumed to originate in the frontal lobes of the brain (predominately the left frontal lobe) and involves the integration of information which is drawn from all other areas of the cerebrum and midbrain.

Progress in psychology often develops in an interdisciplinary vacuum, independent of knowledge in other fields. In many cases, this is to the detriment of psychological theorizing and explanation of observable phenomena. The present research is an attempt to integrate the areas of neuropsychology and cognitive psychology, to describe and account for the human planning function. This is not a unique investigation as the methodological base for the study lies in the model of cognition recently developed by Das and his colleagues (Das, 1972, 1973c; Das, Kirby and Jarman, 1975) which has roots in the neuropsychological work of Luria (Luria, 1966a, 1966b, 1973a).

Two studies were conducted. The first extends the scope of the Das *et al.* (1975) model by establishing a third dimension which can be called planning using a normal, adolescent sample. The second study examined the differences in the performance of two groups (retarded and nonretarded adults) on both coding, and planning tests.

CHAPTER II

SYSTEMS OF THE BRAIN

Introduction

This thesis is primarily concerned with the human planning function. The objective of this chapter is twofold: 1. to place planning into context with other human cognitive functions; and 2. to provide a theoretical structure upon which the methodology and research may be based.

Two bodies of information may be utilized as contextual referents for planning, namely, neurophysiology and cognitive psychology. Recently, neurophysiologists have moved into various research areas, such as the description of the nervous system as it relates to behavior (Woodburne, 1967), the delineation of the nervous pathways associated with learning (Kupfermann, 1975), and the correlates of encoding, storage and retrieval of information. However, even though research such as this is relevant to education, psychologists seem to be reluctant to adopt a neurophysiological position based heavily on animal studies. In contrast, the cognitive psychologist has speculated in abstraction, about information storage/retrieval and processing within a framework quite removed from physiological mechanisms (Estes, 1975) and have generated many plausible explanations, or models, for the same observable behavior.

A hybrid science, neuropsychology combined the psychological description of human behavior in areas such as perception, memory and intellectual activity, with the information obtained from modern clinical neurology, physiology and biochemistry. Though not distinctly

separate, two branches of neuropsychology appear to have emerged in the western world. One emphasizes a basic experimental approach, while the other is clinically oriented. Both attempt to understand behavior through an examination of basic cerebral mechanisms.

Sherrington and Lashley were pioneers of the experimental approach. Sherrington (1933, 1947) proposed that behavioral complexity was directly related to the organization of the junctional connections (synapses) between neurons. Excitation and inhibition cooperate at nodal point after nodal point in nerve circuits to direct the conduction pattern, and consequently, motor outcome. Lashley (1933) stressed the integrated nature of the brain suggesting that cortical tissue was mutually dependent, so that within the entire cortex, for certain functions (and specialized areas for others), subordinate parts are capable of performing functions of the whole.

Sperry and his colleagues (Sperry, Gazzaniga and Borgen, 1969), finding that the corpus callosum enables the transfer of information between hemispheres, demonstrated marked differences in the manner in which information was processed by each; the left handles verbal information and the right, visual-spatial tasks. More recently, Levy, Trevarthen and Sperry (1972) have suggested that each hemisphere can use different cognitive strategies to solve the same problem. Gazzaniga (1975), reviewing split-brain research, concluded that the cerebral areas which process raw sensory information can be isolated and disconnected. However, processes which involve small cortical cells, are more difficult to isolate, as are the channels through which such information can be mediated.

The second approach evolved in response to practical problems of

assessment and rehabilitation of patients with cortical brain dysfunction and reflects the roots of clinical psychology (Smith and Philippus, 1969). Clinical neuropsychology seems to have gained much impetus from attempts to diagnose and rehabilitate brain damaged soldiers following World War I. The major thrust in this area has been the development and description of testing instruments which identify and localize brain damage. Over the past fifty years a multitude of measures have been administered to patients having lesions in various cortical areas and diagnostic, and screen batteries have been proposed (Halstead, 1947; Lezak, 1976; Reitan and Davidson, 1974; Spreen and Benton, 1965). The clinical application of many screening tests is compromised by the number of false decisions made when identifying brain damaged patients, a significant drawback.

The psychometric approach, however, has led to an understanding of various cortically-based disabilities. Benton, for example, conducted extensive research on visual-spatial, and verbal skills associated with aphasia (1965, 1969), constructual apraxias (1967) and dysfunctions associated with the frontal lobes (1968). Benton's findings have suggested integrated brain activities and have parallelled Sperry's in the area of hemispherical dominance and functions.

The work of the late A. R. Luria and his research reported herein, is more closely aligned with the clinical, than the experimental stream in neuropsychology. This approach enables the examination of disturbances in complex human behavior resulting from brain damage or disease, and permits cognitive theorizing based upon physical evidence. Such a methodology provides a powerful theoretical position upon which human planning may be examined.

Two specific approaches to neuropsychology and cognitive psychology will be used: First, Luria's neuropsychology provides evidence for the origin of the planning function within the brain; second, the information-integration model of Das, Kirby and Jarman (1975) supplies the method and framework for interpretation of the data. By combining these approaches, stability of direction and validity of interpretation of results may be achieved.

This chapter is divided into four sections:

1. Luria's Neuropsychological Approach provides the physiological context in which planning may be considered. In addition, Luria's approach to brain functions demonstrates the relationship between cortical areas and intellectual processes;

2. A Cognitive Approach to Brain Systems presents the Das *et al.* model and associated research which furnished the framework in which the relationship between planning and other coding processes may be examined. This model provides the methodological context for the study;

3. Frontal Lobe Damage and Cognitive Dysfunction deals with the relationship between brain damage and intellectual impairment as it relates to planning and volition; and

4. A Summary reviews the more important aspects covered in sections one through three.

Luria's Neuropsychological Approach

Over the past one hundred years, scientists have catalogued the multitude of symptoms which have been identified with local brain lesions in man. The study of isolated symptoms, however, has not led to a reliable method of locating the cause of a disability within the brain. The reason for the apparent confusion created by the single-symptom approach seems to lie in the systemic nature of the brain functions; there exists an intimate relationship between cortical zones and subcortical structures, each aspect contributing an important factor to the completion of any activity. Damage to any structure or zone within a system will be manifested by different cognitive deficits according to the focus of the injury.

Luria (1973b) proposed that the study of local brain pathology using a syndrome approach would remove the confusion created by the single-symptom approach and yield more reliable conclusions regarding the structure of the mental processes affected by trauma. Luria's model of brain activities was developed from the accumulated results of many syndrome analyses. It is based on the idea that mental functions result from the establishment of connections between many cell groups which are often located in distant areas of the brain. These complex networks are called functional systems. Luria proposed that each area of the brain concerned with a functional system introduces its own particular factor which is essential for normal, correct performance. Destruction of a specific mediating zone, while not necessarily causing a total breakdown in the normal performance of the system involved, may cause the loss of some capabilities while others are left intact.

On the basis of his clinical observations of patients with lesions in various parts of the brain, Luria identified three functional systems (Figure 1). In general terms, these units control: the regulation of body tone and wakefulness (Block 1); obtaining, processing and storing information (Block 2); and, regulation of the cognitive activities of the brain (Block 3). Each of these units is organized into hierarchical zones. The primary (projection) zone receives and transmits electrical impulses to the periphery. The secondary (projection-association) zone represents the areas in which information is processed or plans are prepared, and the tertiary (or overlapping) zones connect a number of areas and are responsible for the most complex forms of mental activity. Each unit (functional system) will be described briefly below.

The first functional system of the brain (Block 1)

With the mapping of the activities of the reticular formation by Magoun and Moruzzi in the late 1940's (Magoun, 1963), the importance of the sub-cortex and the brainstem in maintaining and regulating cortical tone at an optimal level was established. This discovery supported the principle of vertical organization of the brain structures and led to the isolation of the first block of the brain.

The reticular formation assists in maintaining the optimal tonal balance of the brain through three sources of activation. The first is the metabolic processes of the organism which maintains the homeostatic balance. The second activation system is related to the arrival of stimuli from the environment. This activation enables the organism to meet surprises and is an important basis of investigative activity. A link is therefore made between the environment and the mechanisms of

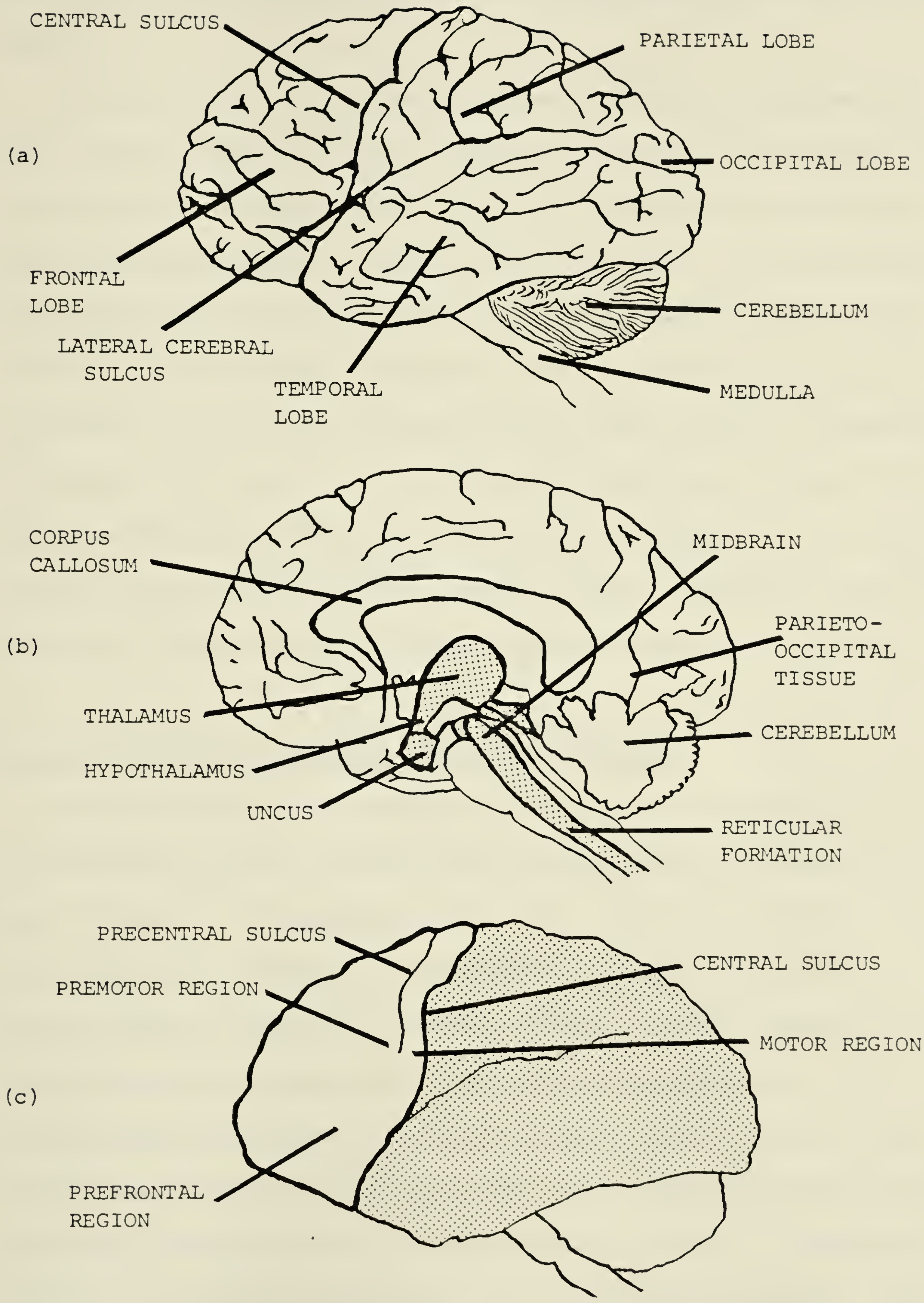

Figure 1. Major blocks of the brain: (a) gross anatomy; (b) the first block; (c) the second (shaded) and third blocks. (After Luria, 1970a)

memory, and specific cortical areas, via the afferent (ascending) connections.

The third source of activation is coupled with the organism's intent; with the forming of plans, programs of action or intentions. The development and implementation of plans, or goal-directed activity requires the maintenance of a certain level of energy. It is in maintaining the optimal energy input that the efferent (descending) fibres of the reticular formation become important. These connections, apparently originating in the frontal regions of the cortex, transmit the regulatory intentions of the cortex to the subcortical structures. Luria (1973b) refers to these descending fibres as the means through which the higher cortical levels engage the lower systems, thereby modulating their functioning and effecting the most complex forms of conscious activity.

The second functional system of the brain (Block 2)

Located in the lateral regions of the neocortex, posterior to the central sulcus, Block 2 includes the occipital (visual), temporal (auditory) and parietal (general sensory) lobes. This unit consists of the systems which have adapted to the reception, analysis, and storage of specific sensory information: visual; auditory; general sensory; olfactory and gustatory, though the latter two are less prominent. The neurons within these lobes or regions respond only to the specialized stimuli characteristic of the particular sense represented and are hierarchically arranged into one of three levels or zones: 1. primary projection; 2. secondary association; or 3. tertiary overlapping. Each of these will be described briefly below.

The primary zones of each cortical region predominately contain

cells which are highly modally specific. They only respond to stimuli having narrow, specialized properties (for example, to a particular tone, or direction of movement) depending upon the modality they represent. Superimposed above these primary layers are the secondary or gnostic levels. They contain less modally specific (associative) neurons which enable incoming stimuli to be organized into functional patterns. Human gnostic activity is polymodal in character and relies upon connections made between the cortical regions and levels.

The tertiary level of neurons performs the integrative function between excitations within the different regions. These zones lie on the boundaries between the occipital, temporal and postcentral cortex and are concentrated in the inferior parietal region. The primary function of these zones is to organize discrete impulses entering the various regions and convert successive stimuli into simultaneously processed groups. In the posterior regions, these zones transform visually or successively represented material into symbolic units. This includes the conversion of concrete information into abstract thinking and permits language operations, the development of grammatical and logical structures, and comprehension of mathematical relationships.

In proposing these mechanisms, Luria (1966a) supported Sechanov's earlier position which postulated that the temporal, and occipital-parietal regions of the brain integrate incoming information (for example, auditory and to some degree, motor input) into successive series while the occipital and parietal lobes combine stimuli (especially visual, and tactile) into simultaneous groups for analysis and synthesis. Each area in Block 2 appears to act interdependently to inform the organism of environmental conditions (including objects and events).

Luria's clinical investigation of brain activities led to the proposal of three general laws governing the working structure of Block 2 (and also Block 3). These are the laws of: 1. hierarchical structure of the cortical zones; 2. diminishing specificity; and 3. progressive lateralization of functions (Luria, 1973a).

The third functional system of the brain (Block 3)

Block 3 comprises the cortical areas anterior to the central sulcus, and facilitates the organizational aspects of conscious activity. Such activities in man involve: the creation of intention; the formation of plans and programs; the regulation of behavior according to these plans; and the checking or verification of a plan or program in achieving the desired results. The frontal cortex is divided into three zones, analagous to those described in Block 2: 1. the motor projection; 2. secondary premotor; and 3. the prefrontal division.

The outlet channel for the prefrontal region is the motor cortex, located immediately anterior to the central sulcus in the prefrontal gyrus. This cortical area is projectional in character and contains the giant pyramical tract of fibres which runs to the spinal motor nuclei, and then to the muscles. Whereas in Block 2, the impulse trajectory is mainly afferent (the excitation passing from the primary to the secondary, to the tertiary zones), Block 3 is largely an efferent system. Plans are formulated in the tertiary (prefrontal) and secondary (premotor) zones and are subsequently passed to the primary (motor) zone which transmits motor impulses to the effectors. The second characteristic is the absence of modally-specific zones previously identified with individual analysers; it consists entirely of efferent, motor systems.

The secondary zone of Block 3 is the premotor area which consists of small pyramidal cells. It plays an organizing role (of movements) similar to the secondary zones of the posterior regions which transform information into functionally organized units. Stimulation of the premotor area causes the firing of groups of systematically organized movements such as grasping movements of the hand; or eye, head or whole body movements.

The tertiary zone of Block 3 is localized in the prefrontal division of the brain, sometimes called the frontal granular cortex because of the lack of pyramidal cells. This cortical area is chiefly responsible for the formation of intentions, plans, regulation and verification of behavior. The prefrontal region has a vast system of two-way connections with all other parts of the cortex. It is, therefore capable of receiving input from all over the brain, and initiating efferent impulses through the premotor and motor areas. Using the linkages with Block 1 through connections with the reticular formation, the prefrontal cortex is intimately involved in the regulation of the active state. Through connections with other cortical areas, the frontal lobes may be regarded as the superstructure above all parts of the cortex, performing the more universal function of general behavior regulation.

Conclusion

This section described Luria's functional organization of the brain. In summary, Block 1 (brainstem regions) is involved with the maintenance of bodily tone and activity; Block 2 (regions posterior to the central sulcus) accepts environmental input, and transforms and stores information; and Block 3 (anterior to the central sulcus) controls motor output,

integrates information from other regions, and is responsible for the formation of plans and regulation of behavior. The identification of the prefrontal region with the human planning function provides the physiological focus upon which this research is founded.

A second reference point may be drawn from Luria's notion of diminishing specificity of neurons which accounts for the higher order function of organizaing impulses entering the various cortical regions. It is the consideration of zone 2 (association) and zone 3 (overlapping) functions which provides the link between neuropsychology and cognitive psychology, since these zones in Block 2 are concerned with coding processes. Of particular interest are the tertiary zones which transform material into symbolic units by processing pieces of information presented serially (successively), or at the same time (simultaneously), independently of the initial presentation mode.

Das (1972) adopted Luria's conceptual framework and proposed an information processing model to account for factor analytic results which could not be explained by previously accepted cognitive approaches. Since then, Das and his colleagues have delineated simultaneous and successive synthesis, two cognitive correlates of processes assumed to occur in zones 2 and 3 of Block 2. Although Das' model also incorporates an analogue to Block 3 (a planning and decision-making component) more interest has been channelled into research on the two coding processes associated with Luria's Block 2.

The next section presents the information processing model developed by Das and his colleagues and summarizes confirmatory research findings. This model provides the methodological context and the research orientation for the studies reported herein.

Information-integration model

Little interest has been shown in Luria's neuropsychology in Western countries and hence, investigation into the various cognitive functions described therein, from the Russian perspective, has been minimal. One exception has been the information-integration model [Das, 1972, 1973c; Das, Kirby and Jarman, 1975 (see Figure 2)] which has historical roots in Luria's clinical observations of lesions in the occipital-parietal areas (producing disturbances in the simultaneous organizations of stimuli) and in the fronto-temporal areas of the cortex (producing disturbances in successive processing) (Luria, 1966a, 1966b; Luria, Sokolov and Klimkowski, 1967).

The terminology and the premise that the specified posterior cortical areas facilitate simultaneous and successive processing is a major aspect of the information-integration model. Over the past ten years, the research conducted by Das and his colleagues has demonstrated commonalities between tests which appear to require sequential processing (for example, in recall of auditory and visually presented words and digits), and whole unit processing (for example, in reproduction of visually presented diagrams). The pattern of the relationships between the tests has remained stable across various ability, age, and ethnic groups and seems to fit the systemic physiological model proposed by Luria (Das *et al.*, 1975; Jarman and Das, 1977; Kirby and Das, 1977).

Four basic components are hypothesized in the information-integration model: input, sensory register, central processor, and an output unit. Stimuli are accepted through any receptor, that is, intero-, proprio-,

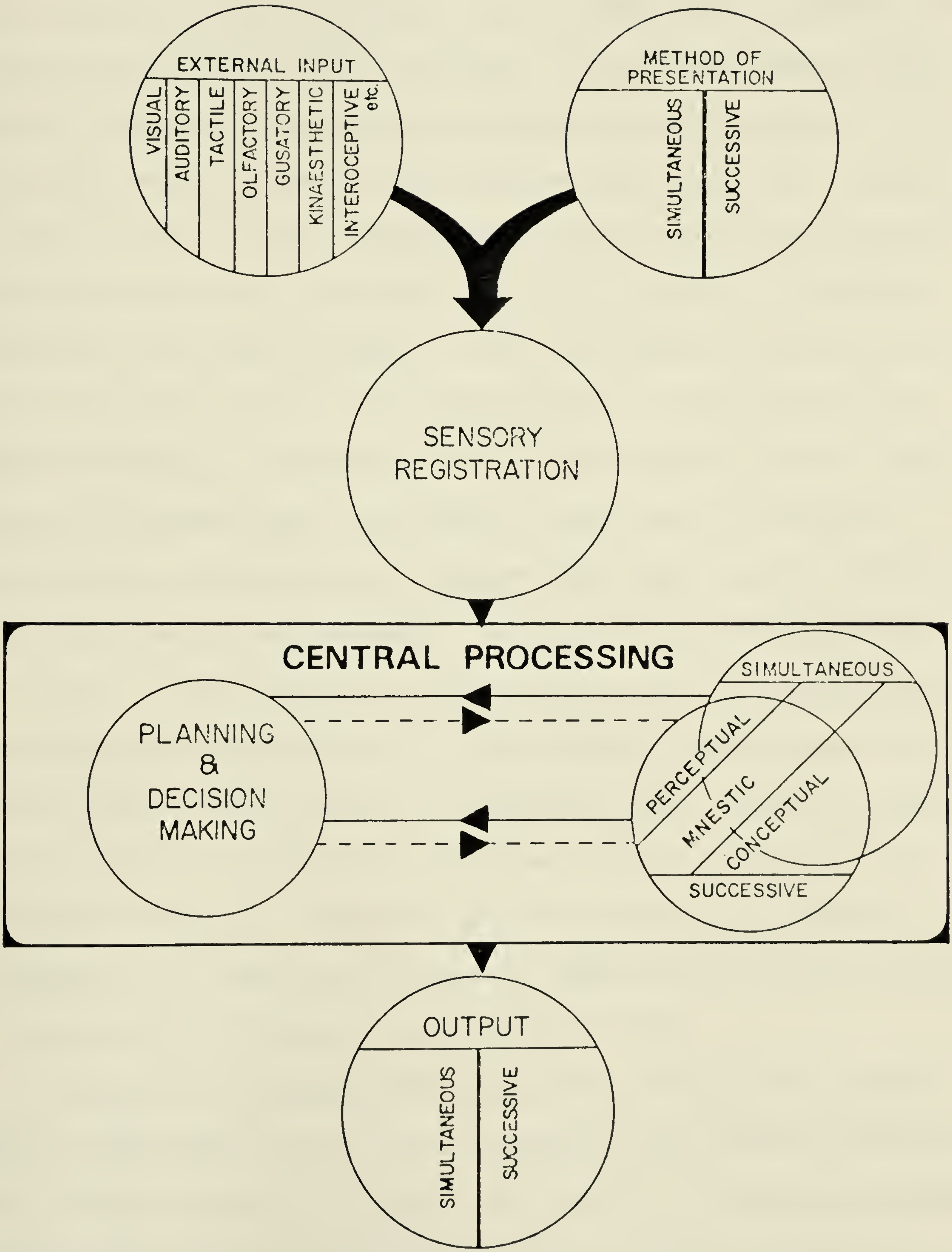

Figure 2. Model of information integration

exteroceptor modality, and may be presented in either simultaneous or successive manner (Figure 2).

Stimuli are immediately transmitted to the sensory register (which might incorporate zone 1 neurons), and are passed into the central processor which comprises three components: a unit which mediates simultaneous information, and one which processes discrete information into successive series (the coding unit which may use zone 2 and 3 neurons of Block 2); and a third component which acts upon information passing from the previous two, and is referred to as a planning and decision-making unit (analogous to Block 3, zone 3 functions). The output unit might incorporate Block 3, zone 2 and 1 neurons. Processing by the coding components is independent of the form of sensory input. Simultaneously presented input (for example, visual) may be synthesized successively, and successively presented input (for example, auditory) may be dealt with simultaneously. The choice of processing mode depends upon: 1. the individual's usual practice which is socio-culturally and genetically determined; and 2. task demands. Simultaneous synthesis refers to the integration of information into spatial or quasi-spatial groupings in which the various parts of the synthesis are immediately surveyable. Successive synthesis refers to the coding of information in a manner which preserves temporality so that the system is not surveyable totally at any one point in time.

Das and his colleagues (Das, 1972, 1973a, 1973b, 1973c; Das and Molloy, 1975; Kirby and Das, 1977; Krywaniuk, 1974; Krywaniuk and Das, 1976; Jarman and Das, 1977; Leong, 1974; Williams, 1976) have conducted studies which have led to the development of a coding (simultaneous-

successive processing) battery of tests. They have examined the relationships between these two modes of processing with samples from different age, ethnic, socio-economic status and ability groups. A representative factor analysis using the coding tests is presented in Table 1 below.

The three factors which have emerged (Das *et al.*, 1975) were identified as successive processing, simultaneous processing and speed. The first factor (successive) is characterized by serial recall, free recall and visual short-term memory for numbers. It is neither modality specific nor a general memory factor as the test, Memory for Designs (a short-term memory test for geometric designs), does not load on this factor. Digit Span (a test of short-term memory for numbers) also loads on this successive factor when administered (Das and Molloy, 1975). The The second factor (simultaneous synthesis) is identified by Raven's Progressive Matrices, Figure Copying (involving the reproduction of geometric shapes), Memory for Designs, and cross-modal coding (a measure of auditory-visual integration). These tests share a need for processing whole patterns at once rather than in series. The third factor is represented by word reading and color naming and is interpreted as a speed factor.

Similar factor structures have been established using samples of low ability children (Das, 1972; Jarman and Das, 1977; and Jarman, 1978, in press), disabled readers (Leong, 1974), high and low school achievers (Kirby and Das, 1977), children from high and low castes in India, Canadian blacks (Das, 1973a), and Canadian Indians (Krywaniuk, 1974). Working within the same model, Cummins (1973) factor analysed a battery of tests different from the coding tasks, such as tests of logical syllogisms,

TABLE 1

Simultaneous, Successive and Speed Factor Structure using
Grade 1 (N=60) and Grade 4 (N=60) Children, after Krywaniuk (1974)

Variable	Successive		Simultaneous		Speed	
	Grade 4	Grade 1	Grade 4	Grade 1	Grade 4	Grade 1
Raven's Progressive Matrices	-.042	-.146	.873	.784	.013	.088
Figure Copying	-.031	.290	.757	.762	.147	-.108
Memory for Designs (errors)	.162	-.199	-.706	-.713	.190	.394
Cross-Modal Coding	.267	*	.665	*	.087	*
Visual Short-Term Memory	.710	.060	.021	.163	-.192	-.557
Word Reading	-.112	-.287	.035	.046	.973	.766
Serial Recall	.934	.951	-.045	.101	-.009	-.166
Free Recall	.927	.955	.003	.051	.011	-.108
Color Naming	*	-.161	*	-.067	*	.801
% of Total Variance	29.4	25.6	28.5	21.9	13.1	21.9

* test omitted

divergent thinking, paired associate learning and similarities. He identified three factors: divergence, simultaneous processing, and successive processing.

These data provided the basis for an information processing approach incorporating both coding and planning functions. While the structure of the coding dimension remains stable across various groups, performance differences do exist between groups. This implies a quantitative, rather than a qualitative difference on the simultaneous and successive (S-S) dimensions. While several studies (Das, 1972; Jarman and Das, 1977; Jarman, 1978d) indicate that qualitatively similar cognitive processes are used by individuals with a wide range of intellectual competencies, other literature (for example, Kirby 1977) implies that qualitative differences in information processing might also exist, and may be revealed by an examination of the planning aspects of human cognition.

Jarman (1978c, 1978d) suggested that the consistency in the findings on the coding dimensions is partly due to the homogeneity of tests used to define the processes. Homogeneous measures demonstrate the generality of processes between, for example, retarded and non-retarded subjects. In effect, such tests might be viewed as "pure" measures while heterogeneous tasks are sensitive to the variation between groups on cognitive processes. Simultaneous and successive syntheses, therefore represent the most basic means of coding information. Jarman concluded his study by stating that little is known about the use of simultaneous and successive processing in tasks that require effective strategic behavior.

Efficient utilization of processes may be demonstrated, in part, by successful performance on tests, but an additional cognitive process

may be inferred which intermediates efficient use of strategies. This process is planning.

Smirnov and Zinchenko (1969) demonstrated that people facilitate retention and recall of information by a variety of approaches. When subjects were asked to recall information accurately, very elaborate plans were generated. When casual reproduction of material was required, a general scheme rather than an elaborate plan was used. This suggests that their subjects had the option of structuring encoding and decoding according to task and environmental demands. Mentally retarded individuals do not demonstrate the same flexibility in planning strategic behavior and hence, an examination of planning using mentally retarded subjects may shed considerable light on the relationship between coding and planning processes.

Brown (1974) drew attention to the significance of strategic planning by proposing that performance deficits found in mental retardates resulted from the inefficient use of control processes, active mediational devices and strategic transformations of input. She proposed that training in the use of rehearsal, organizational strategies, and intentional nonprocessing of irrelevant materials (all strategic patterns under the individual's voluntary control), would produce a significant decrease in performance differences between retarded and normal subjects. Brown confirmed her hypothesis in a series of studies and demonstrated the utility of the deliberate effort to train retardates in the effective use of strategies and plans.

The clinical characteristics of mental retardation described by Luria (1963) are surprisingly similar to those found in frontal lobe patients, and referred to as planning deficiencies. Deficits in planning

were raised by Lubovsky (1974) in relation to the transition from external to internal verbal control in mentally retarded children. Planning for future activity was viewed as the highest form of verbal control of behavior. Das (1973d) agreed that planning and structuring one's behavior to fulfill plans are characteristics of intelligent people and concurred that planning was the highest of human activities. He questioned, however, whether the mentally retarded could be trained in such an activity, recognizing the usual conditions of existence and the wide range of planning efficiencies found among non-retarded groups.

An examination of the information processing in the mentally retarded raises an important issue regarding the interdependence of coding and planning. Das' model has provided a useful means of delineating coding while Brown (1975) and later Kaufman (1978) demonstrated that it is possible to teach mentally retarded children effective strategies for dealing with information encoding and retrieval. In a sense, such training is viewed as imposing "external" conditions to overcome an "internal" planning deficiency which directs coding. It may be expected, therefore, that mentally retarded individuals would not only show lower performance than nonretardeds on coding tests, but also on planning tasks. The overall process structure, in accordance with Jarman (1978b) may remain the same.

Conclusion

Das and his colleagues have generated considerable data substantiating simultaneous and successive synthesis as a major aspect of cognitive functioning. In addition, their information processing model describes a relationship between these two coding processes and planning and

decision-making. This approach, therefore provided the methodological base for the research reported herein and is viewed as an improvement over correlational studies of cognitive behaviour (for example, Guilford and Lacey, 1947; French, 1951; Adkins and Lyerly, 1952; Berger, Guilford and Christensen, 1957; Guilford, 1969) or solely cognitive explanations of bahavior (for example, Miller, Galanter and Pribram, 1960), which have not produced the key to understanding the human planning mechanisms.

When developing the information processing model, Das and his co-workers drew freely from the neurological literature in an effort to provide the most direct association between brain functions and associated cognitive behavior. This approach appears to be successful in delineating coding and forms the basis for exploring man's intentions, volition and planfulness. Clinical observations of patients with frontal lobe damage and various psychometric investigations of these disturbances provide support for the establishment of an independent planning function. These are reported in the following section.

Frontal Lobe Damage and Cognitive Dysfunction

Various researchers have studied the activities of the brain and the relationship between the anterior and posterior cortex. Livanov and his colleagues (Livanov, 1973; Livanov, Gavriola and Aslanov, 1973) found that bioelectrical correlations between points in the frontal lobe during times of mental activity was high compared to the net of functional connections in the posterior region. The number of correlations dropped in the frontal lobe when Aminasine (a drug used for blocking ascending activating impulses) was administered. Damage to the anterior cortical regions has provided evidence of changes in the orienting and activation reaction (Pribram and Luria, 1973), and changes in excitation of various synaptic structures (Simernitskaya, 1973).

Pribram (1973) accounted for these and other empirical findings in a model of frontal lobe functioning adapted from computer programming. The frontal lobes were viewed as the executive mechanism which mediates the inhibition of interference among brain events. They are concerned with structuring context-dependent behaviors on the basis of environmental input. When lesions occur, breakdowns are manifested in delayed response and alternation tasks in which the frontal lobes must be sensitive to the changes in the conditions and alter the response program appropriately.

These findings and contentions indicate that the frontal lobes may act interdependently with the posterior regions, as well as perform a regulative function. This suggests that disturbances of cognitive activities following frontal lobe damage are concerned with planning. To support this proposition, a number of frontal lobe disturbances will be reviewed. Each of these shows evidence of planning deficiencies and

provides some guidance for measuring planning functions.

Psychological disturbances following frontal lobe damage

From the mid-eighteen hundreds, reports of frontal lobe damage in man have referred to marked disturbances of behavior in the psychological sphere. Harlow (1848, 1868) recorded the classical "crowbar case" of Phineas Gage, a gang foreman for the Rutland and Brulington Railroad, who was tamping gunpowder into a narrow hole drilled in stone when a spark ignited the charge. The rod (one meter long, three centimeters in diameter and weighing over eight kilograms) exploded from the hole, struck Gage beneath the eye and passed from his head approximately ten centimeters above the bridge of his nose (see Figure 3). Though knocked to the ground, he was conscious a few minutes later and able to speak. Because of infection in the wound, Gage was bed-ridden for about three weeks. Two months later he *appeared* to be completely recovered but anecdotal information reported that profound psychological changes in affect and planfulness had occurred though his intellectual faculties seemed unaffected.

Since the Harlow accounts, many examinations of frontal lobe trauma have reported a vast range of symptoms and speculation regarding causation. Fuechtwanger and Kleist (cited in Schlesinger, 1962) studied gunshot wound cases following World War I. Feuchtwanger concluded that frontal lobe trauma had considerable impact on volition and affect though recent memory, test intelligence and attention was largely unaffected. Instead of dwelling on volitional factors as the cause of frontal lobe syndrome, Feuchtwanger ascribed the emotional change to aberations of abstract knowledge, or problems of "will" and values. Kleist's explanation

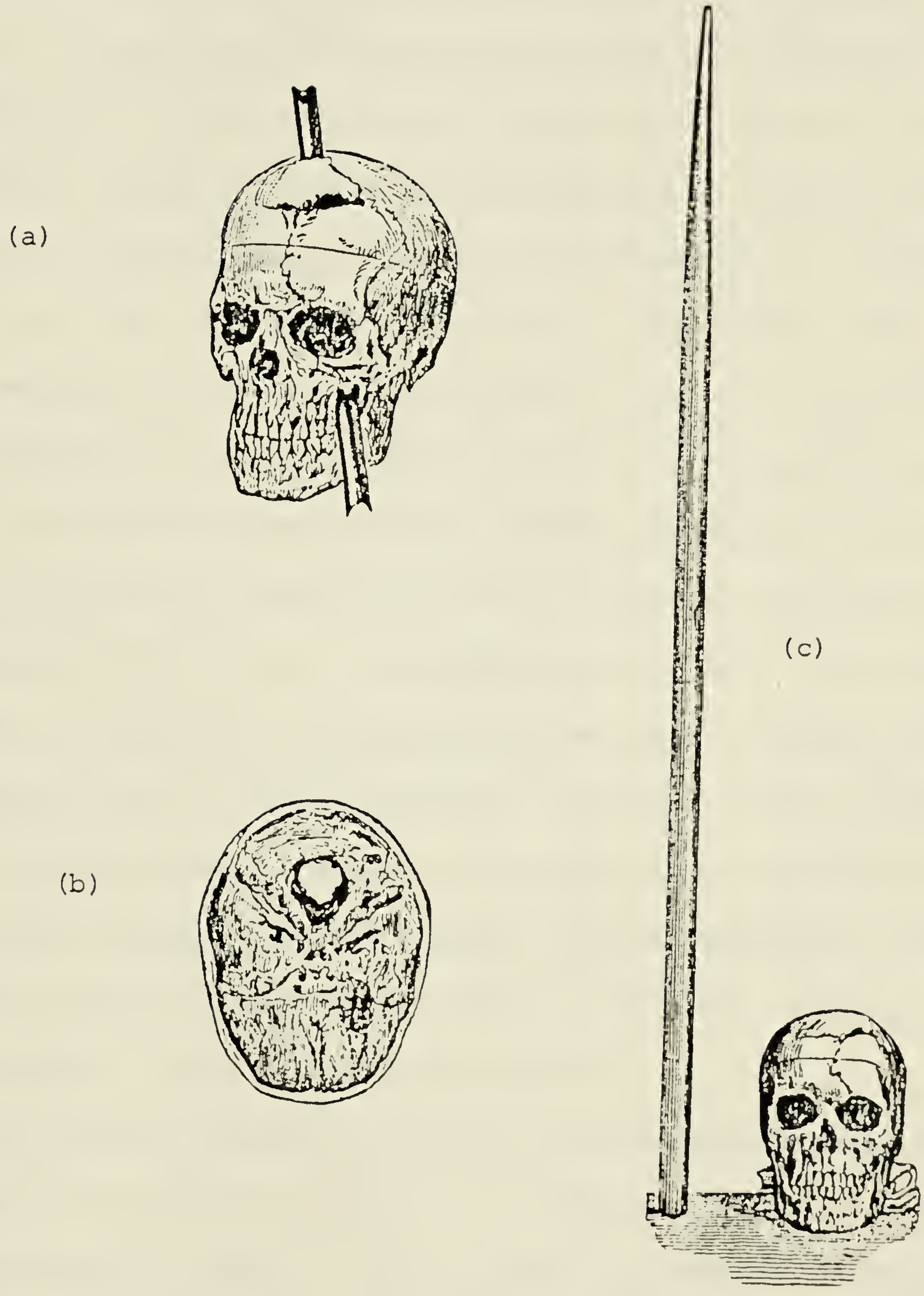

Figure 3. Skull of Phineas P. Gage and Tamping Iron. (a) Front, lateral view of cranium showing passage of tamping iron; (b) View of skull base showing orifice caused by tamping iron; (c) Comparative size of the tamping iron and skull. After Harlow (1868, p.347)

of frontal lobe symptoms was based upon the functional relationship between the somatic and psychic spheres. He proposed a three-level *ego* structure comprising: 1. lower emotions and drives; 2. somatic sensations; and, 3. higher emotions and character traits (sentiments, beliefs). These included both sensory (feelings, drives, enteroceptions, and attitudes) and motor aspects (kinetic activity related to volition and drives). Kleist believed that structural changes of the diencephalon, orbital and cingulate cortex were related to the highest *ego* functions. The diencephalic components of all *ego* levels respond to injury with fluctuations in the excitability of the structures in which they are represented.

When accounting for the behavioral effects of frontal lobe damage, other early studies have reported a loss of initiative and lack of capacity for planned administration (Penfield and Evans, 1934); the destruction of the synthesizer of intellectual operations or engramatic products emanating from the posterior cortex (Brinckner, 1936); interference with the mechanism which is concerned with projection of the individual into the future (Freeman and Watts, 1939); and disintegration of general intelligence, stable personality and affect, initiative, memory, attention, and abstract reasoning (Klebanoff, 1945).

A single frontal syndrome, accounting for all observable behavior, did not emerge from earlier research. Discrepancies in behavior arose primarily from three sources. Damage caused by penetrating missile wounds, by surgical intervention in disease or psychopathology led to disparate symptoms. Similarly, it was recognised that the brain had the propensity to reorganize cognitive systems using remaining normal regions to overcome deficits, and that few focal lesions were so precisely demarcated that they affected only one narrowly localized group of nerve

cells (Hebb, 1945; Hebb and Penfield, 1940). And finally, lesions infrequently destroyed an entire group of cells associated with one system - destruction of some elements occurred while others remained intact.

The following section deals with some of the disturbances noted above. They support Luria's functional organization of the brain and provide research measures which have discriminated frontal, from non-frontal lobe damaged patients, and therefore are face valid tests of planning.

Disturbances of the planning aspects of movement, speech and writing

Through connections with the reticular formation and the motor cortex, the frontal lobes play an important role in the regulation of conscious goal-directed activity (Luria, 1966a). These voluntary movements (which might be single motor acts or series of separate, successive movements) require continual comparisons with the intended results or task demands to ensure correct performance (Anokhin, 1969).

Luria (1966a) asserted that speech is important in the later stages of development of voluntary movement as the former often provides the feedback system and hence performs a regulatory function.

When frontal lobe damage occurs a breakdown in the regulation of speech may occur if it involves the severing of the connections between the frontal lobes and the midbrain. The resulting behavior is characterized by a lack of planning which is manifested by perseverations of motor or speech reactions to irrelevant stimuli.

Luria accounted for the clinical observations of stereotypic behavior patterns and gross disintegration of actions, as exhibitions of pathological inertia of nervous processes which assume momentum over

whole systems. Dominance of old associations are so strong that they disrupt new actions. His findings of disturbances in the selective, goal-directed actions under a variety of conditions indicated that the disruptions most often found result from the patient's inability to initiate and maintain the plan of action. When the regulating influence on behavior is lost, goal-directed actions are replaced by perseverative motor acts which are linked with the patient's past experience.

Luria and Homskaya (1964) found that their frontal lobe patients were unable to mediate Galvanic Skin Response (GSR) [a measure of the orienting reflex (OR)] and plethysmographic records through speech. Both records showed poor response by frontal lobe damaged patients to unaccustomed stimuli in contrast to the near regular patterns elicited from patients who had lesions in the posterior regions of the cortex. Verbal instructions to the frontal lobe damaged patients produced no significant change to the vegetative component of the orienting reflex. With patients carrying less profound lesions, verbal instructions produced only slight and temporary stabilization of the OR. The observations indicated the impact of the loss of the self-regulatory function of the frontal lobe, and the inability of the patient to engage the memory processes for goal-directed activity.

Related to both speech and movement is the ability to write. Lesions of the frontal lobes usually do not lead to writing disorders *per se*, but are reflected in disintegration of higher functions which may lead to micrographia (writing progressively smaller and smaller letters) or the loss of an overall plan of action which may be manifested by perseverations. Luria (1971) reported that patients transposed letters, were unable to move from one letter to another when forming words, and often

replaced the required letter with a meaningless stereotype. If the lesion is located deep in the brain, the interruption of the connections with the brain stem and the cortex makes the patient incapable of writing. The expression of thoughts and ideas are also impaired by severe lesions. Luria reported a letter written by a patient to a Russian neurosurgeon which read: "Dear Professor, I want to tell you that I want to tell you that I want to tell you..." for many pages. Similar perseverations have been found using geometric figures as the stimuli.

The analysis of writing and of speech is one aspect of the psychological exploration of frontal lobe damage which seems related to an intention or a plan. Information held in the posterior regions of the brain requires recoding and structuring into a verbal or written form. When damage to the mediating cortex occurs, there can be no spontaneous, creative speech or writing though repetitive speech and the naming of objects may remain intact; and the phonic, lexical or logical grammatical functions of speech [which are disturbed by lesions in the posterior area (Luria, 1970b)] remain unaffected. For the above reasons, tasks requiring creative writing, and creative speech were included in the test batteries administered to the subjects in the studies reported herein. The procedures used will be outlined later.

Disturbances of the planning aspects of sensory discrimination

Perception is often understood to be a relatively passive process primarily conducted by the sensory divisions of the cortex. In contrast, Luria (1966a) proposed that sensory discrimination was an active process, mediated by the frontal lobes. This involves a sequence of tasks including: the search for the most important aspects of information; comparison

of each part with others; creation of hypotheses related to the meaning of the data as a whole; and the verification of hypotheses by comparison with the original features of the perceived object. As a result, frontal lobe damage causes impairment of sensory discrimination involving for example, visual and tactual senses.

Patients with frontal lobe defects do not show dysfunction with visual perception; they recognize simple pictures, letters and numbers and read simple words and sentences without difficulty. However, when complex tasks are presented, patients' visual scanning becomes passive and they act impulsively, without considering all dimensions. These deficits characterize a loss in the ability to plan. Yarbuss (1967) supported this position when he recorded the eye movements of normal and frontal lobe patients when viewing a photograph. Similar disturbances of active eye-scanning were described by Teuber, Battersby and Bender (1949) using a visual search task and by Teuber (1960). They identified lasting deficits in visual search patterns of brain damaged individuals. Teuber (1964) using frontally-damaged patients, demonstrated a significant reduction in speed and efficiency of search, which appeared independently of gaze fixation.

Teuber's visual search task required patients to view a projected field of forty-eight patterns and locate a duplicate of one of the patterns through active searching. Frontal lobe patients demonstrated a significant reduction in speed and especially in the efficiency of the search. A similar task was developed for the research reported herein.

Patients with severe frontal damage experience difficulty in perceiving visually presented geometric figures, letters or numbers. Luria (1966a) described clinical observations of patients who perseverated and inertly

transferred the properties of one figure to another. Both Teuber's and Luria's findings suggest that the more complex activity of perception requires a planned approach to perceive the material.

Planning deficits in tactual perceptions have also been recorded. Luria (1973a) reported the work of Tikhomirov who presented patients with two checkers on which there was a form of one of two letters. They were required to touch the blocks successively and identify the letters. Normal subjects very quickly established a strategy for identifying the most critical aspects of the forms while frontally-damaged subjects failed to establish strategies or shorten their search time, merely guessing at the answer in each trial. Their hypotheses regarding the form did not act as a starting point for the search and the verification process and in effect, no plan of action was generated for successful task completion.

Disturbances of the planning aspects of intellectual processes

Disturbances of intellectual processes following frontal lobe damage were reported by early writers (for example, Feuchtwanger, Klebanoff). Over the past sixty years, no other area has received more attention, or has been so easily tested. Considerable discrepancy has been found in results, but in general, the most consistent deficit shown by frontal lobe patients is associated with goal-directed activity or planfulness.

Luria (1966a) in concluding a segment using a similar title as above, stated that the intellectual impairment resulting from frontal lobe damage fits uneasily under any single heading. Changes in cognition may be closely related to deficiencies in voluntary movements, gnostic or mnestic processes.

Patients with severe frontal disturbances accompanied by general loss

of cortical tone may exhibit gross memory deficits, for example, fail to identify people correctly or give incorrect information about their last address. An examination of voluntary memorizing provides the most clear evidence of mnestic (memory) disturbances in cases when primary memory is undisturbed. Patients are unable to create stable motives of recall, sustain effort necessary for voluntary recall or progress from one memory trace to another. When frontal lobe patients are required to learn a long series of spoken or written elements, they do not produce results greater than a series which has created an initial impression upon them, regardless of the number of complete presentations of the material. By examining the mnestic activities of normal subjects, the planning deficit of frontal lobe patients in this area becomes apparent. Normal subjects concatenate series to increase the length of the remembered material (for example, memorizing lengthy passages from Shakespearean plays) thereby applying strategies which aid recollection. The use of strategies implies a structured or planned approach which is missing when damage to the frontal regions occurs.

Various studies have examined different aspects of the intellectual processes in brain damaged patients using psychometric techniques involving the administration of test batteries believed to be sensitive to trauma in various locations of the brain. These have included, for example, abstract versus concrete thinking and generalization (Goldstein, 1936a, 1936b; Nadel, 1938; Teuber, Battersby and Bender, 1951; McFie and Piercy, 1952), and intellectual deterioration using intelligence tests (Ackerly, 1935; Lidz, 1939; Worchel and Lyerly, 1941; Halstead, 1940, and Rylander, 1939, reported by Klebanoff, 1945) with differing conclusions.

Armitage (1946) administered a battery of tests to cerebrally-damaged patients, classified according to severity of injury and location of trauma, and a control group of normal hospital attendants. Though he failed to report a data analysis according to the site of trauma, Armitage claimed that tests of Memory; Trail-Making; Patch; Goldstein-Scheener Cube; and Stanford-Binet Vocabulary discriminated between groups. Examination of the results suggest that this claim is slightly optimistic; the first three tests performed satisfactorily, while support for the last two is questionable.

The Trail-Making test presages later findings of Luria and his co-workers with frontal lobe patients. Armitage reported that this test measured the ability to perceive a double relationship, to plan, to shift between rules, and was sensitive to perseveration. To perform satisfactorily, it was necessary to look ahead and form a quick, overall plan. Others (Reitan, 1955; Knights, 1966; Spreen and Geddes, 1969) more recently, have included the Trail-Making in a battery of tests thought to identify patients with brain damage. This test was also used in this study to focus directly on strategies for planning.

Porteus and his colleagues (Porteus, 1955, 1965; Porteus and Kepner, 1944) conducted several examinations comparing subjects' pre- and post-operative performances on intelligence tests and the Porteus Maze Test. Finding that the latter was sensitive to frontal lobe damage, Porteus asserted that his mazes tested planning, initiative and foresight.

Milner (1964) disagreed with Porteus' assumption regarding the link between Maze performance and planning though she stated that the Stylus and Porteus Mazes are closely related. She proposed that the performance deficit is related to the subjects' inability to inhibit impulsive

responses while normal cues are disregarded, thus promoting perseverations. She found that subjects with lesions in the frontal lobes consistently showed a definite tendency to be unable to suppress on-going response tendencies, whether they are produced spontaneously or experimentally. Frontal lobe patients also have difficulty generating words within given dimensions and consequently demonstrate a reduction in spontaneous speech. As this finding is supported by Luria, Thurstone's test was included in the batteries used in the research reported herein.

Milner speculated that the production of normal behavior is dependent upon the simultaneous functioning of many complex sets, each being capable of initiating action if one system malfunctions. She suggested that frontal lobe injury reflects this modulatory function in conjunction with adequate performance on standard intelligence tests.

Throughout the literature review, one recurring feature of the effects of frontal lobe damage was the apparent loss of inhibition or regulation in the behavior of frontal lobe patients (for example, Schlesinger, 1962; Teuber, 1964; Luria, 1973a, 1973b) manifested by impulsive reactions in cognitive tasks. This characteristic was also found in descriptions of personality or affective changes following frontal lesions or trauma, as either a primary or secondary consequence (for example, Harlow, 1868; Brickner, 1936; Freeman and Watts, 1939; Klebanoff, 1945).

Milner (1964) drew attention to the association between affective and cognitive aspects of frontal lobe damage, and raised the question as to the extent to which personality variables might be involved in the planning function. This issue is dealt with by an examination of one personality dimension.

Impulsivity and planning

Subjects' inability to inhibit impulsive responses in a variety of tasks was described by Kagan and his co-workers (Kagan, Rosman, Day, Albert and Phillips, 1964; Kagan, 1965) as reflection impulsivity. Kagan's postulate describes the tendency to reflect upon the dimensions of a problem when several possible alternatives are available and when some uncertainty exists over which is the most appropriate. Four personality types are identified from a marker test (Matching Familiar Figures Test): Reflective; Impulsive; Fast-Accurate; and Slow-Inaccurate. Testees are divided into one of these groups as a result of the number of errors made, and the time taken in deliberation on the problems. An impulsive person therefore, is one who makes an incorrect decision before all possible alternatives are considered, in a short period of time. A reflective person takes sufficient time to examine possibilities, is more concerned with accuracy than time, and generally chooses the correct response. Fast-accurate, and slow-inaccurate is self-explanatory.

It could be assumed that the reflective person plans efficiently for the study of the problems, while the impulsive conducts a cursory search, stemming from an inadequate planning strategy. Many studies have examined Reflection-Impulsivity (Messer, 1976), a number of which may be relevant to the research reported herein. For example, Weintraub (1973) and Shipe (1971) found that reflectives showed greater success on perceptual and conceptual psychomotor tasks than impulsives. Reflectives have also shown more systematic search strategies, were less reliant on memory and were more successful on serial learning tasks than impulsives (Messer, 1976).

In view of the apparent relationship between impulsivity and

characteristics of frontal lobe damage patients, and the absence of exploratory studies dealing with personality and simultaneous and successive synthesis, the Matching Familiar Figures Test was included in the battery of tests administered to the subjects in Study 1 of this research.

Summary

This chapter dealt with the human frontal lobes as they influence the cognitive function of planning. Recent literature suggested that any single cortical region or area does not carry full responsibility for a specific function, for example, memory. Luria proposed a functional organization of the brain based upon observations of the cognitive deficits presented by temporal, occipital-parietal, and frontal lobe damaged patients.

Das and his colleagues developed an information-integration model using Luria's organization and conducted studies which identified a series of tests believed to measure temporal, and occipital-parietal lobe functions. This study extends the Das *et al.* model by focussing upon the frontal region and its concommitant function as the executive mechanism of the brain which integrates information from the environment, with information held in memory.

Since the mid-1800's, an extensive body of literature has described deficits produced by damage to the frontal lobes. Careful clinical observations by Luria have supported the notion of executive mechanism, and the role of the frontal lobes in planning and decision-making - a role which is reflected in the Das *et al.* information processing model.

This project is divided into two studies; each addresses a different aim. The primary objective of Study 1 was to examine the relationships between tests thought to measure frontal lobe functions, and marker

tests of the two established dimensions of the information-integration model, namely, simultaneous and successive processing. In addition, the relationship between the personality dimension of Reflection-Impulsivity and the coding and planning tests was examined. Study 2 was aimed at examining the relationship between tests using two adult samples: 1. normal intelligence adults drawn from the larger population; and, 2. a group of educable mentally retarded adults.

CHAPTER III

RATIONALE

The general problem of this study is to determine the relationship between planning, coding (simultaneous and successive syntheses), and to a lesser extent, impulsivity. This problem may be divided into two major questions:

1. Is there a single planning dimension, which will exist independently of simultaneous and successive processing?

2. What patterns of similarities or differences exist between diagnostic groups on planning and coding tasks?

The research and writings of Luria and other neuropsychologists have provided the clinical basis and the psychometric tools for examining the process of planning in man. In addition, a link between the frontal lobes of the brain and the human planning function has been established by the analogue offered by the information-integration model described by Das, Kirby and Jarman (1975).

More specifically, Luria's clinical observations and other empirical data have demonstrated that damage to the frontal region has significant effects upon normal cognition. Though the coding mechanisms appear to remain intact (for example, basic memory and perception), synthesis, analysis and the enactment of strategies to deal with environmental and task demands is a deficit associated with frontal lobe damage. These findings may be interpreted in Das' model as a break in access of the planning or thinking component to coded information.

Over the past thirty years, specific tasks have identified frontal from non-frontal lobe damage patients. These tests appear to require

strategic behavior or planning for successful performance. Question 1 is directed towards examining the relationship among a number of these tests with the aim of establishing a unitary planning factor.

The Das *et al.* approach to the study of planning has two important advantages. First, the discovery of a stable structure for simultaneous and successive factors (in varying ethnic, socio-economic and ability groups) at least suggests underlying ways of dealing with problems, and by inference, basic coding processes. Secondly, studies have demonstrated that simultaneous and successive factors can be extracted from a variety of test batteries (cf. Cummins, 1973; Das *et al.*, 1975; Kirby, 1976) suggesting a processing standard to which other tests may be referenced. Planfulness, as measured by selected tests, may be related to simultaneous and successive synthesis, thereby signifying that alternative approaches to planning and frontal lobe deficits would require further examination. A secondary issue of Question 1 is an exploration of the relationship between Reflection-Impulsivity and planning and coding tests.

The degree to which a person deliberates over a problem may be viewed as an indicator of the extent to which synthesis, analysis and generation of alternative solutions is being considered. A number of suppositions are possible regarding the efficiency of coding and planning of such persons. Kagan proposed a personality dimension which identified reflectivity and impulsivity in problem-solving situations in which speed and accuracy of task performance compete. While no specific hypotheses are offered, performance of the planning task might vary inversely with impulsivity, while the relationship between coding and impulsivity would be small or insignificant.

With determination of planning and coding factors, it is possible

to examine the differences found between normal and mentally retarded subjects. There is evidence to suggest that retardates not only experience coding difficulties (Jarman, 1978d) but also, do not develop adequate strategies for dealing with a variety of task demands (Brown, 1974).

Previous research using the simultaneous-successive battery with retarded subjects (Das, 1972; Jarman, 1978d) has shown a factor structure similar to that which is found using non-retarded subjects. With the addition of planning tests, a third factor is anticipated which should appear consistently across a retarded and non-retarded sample. Question 2 specifically addresses this issue. While no specific hypotheses will be presented, it is expected that a confirmatory factor analysis will be consistent with previous findings, while retarded and non-retarded group means will discriminate significantly on the planning factor as well as on the simultaneous and successive factors.

CHAPTER IV

STUDY 1: METHOD AND RESULTS

Method

Subjects

The principals and teachers of three urban junior high schools consented to allow their students to be tested. Five Grade 8 classes were chosen with a total enrolment of 120 students (approximately half male, half female), within the age range 13 to 15 years. These three schools draw pupils from a cross-section of socio-economic areas from relatively low-middle to upper-middle class. Age and IQ data for each subject was collected from student records and is summarized in Table 2. One hundred and four subjects were used in the study - sixteen were excluded due to absence from one testing session or missing biographical data.

Procedure

The following five tests were selected for the planning battery: Porteus Maze Test, Visual Search Task, Trail-Making Test, Verbal Fluency, and Planned Composition. Figure Copying and Memory for Designs comprised the marker tests for simultaneous processing and Auditory Serial Recall, Visual Short Term Memory, and Digit Span were selected as markers for successive processing. Matching Familiar Figures Test and simple Reaction Time were included in the complete battery to explore the personality dimension.

All testing was conducted at the school attended by the participating children and all tests were administered to each subject. Testing in class-size groups took place in the students' home rooms for four

Table 2

Means and Standard Deviations of Age, Verbal IQ and Nonverbal IQ, for Males, Females, and Total Sample (N=104) for Study 1.

Variable	Males		Females		Total Sample	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Age (months)	164.3	5.99	164.4	5.79	164.3	5.89
Verbal IQ*	105.0	13.25	104.3	13.42	104.6	13.34
Nonverbal IQ*	112.8	11.94	109.2	13.99	111.0	13.13

*IQs were derived from the Lorge-Thorndike, which was administered by School Board personnel in 1976. In four cases, WISC scores were available.

classes, and in a teachers' library for the fifth. Approximately fifty minutes for each group testing period was required. This was achieved in two sessions for four classes, and one session for the fifth. The essay (Planned Composition) was written first, followed by the Visual Short Term Memory test, Memory for Designs, Figure Copying, Verbal Fluency and Digit Span.

Individual testing was conducted in two adjacent rooms for all groups because of the necessity to have a darkened area for the Visual Search Task. The total individual testing time for each subject varied, according to the time taken for the Matching Familiar Figures Test (MFFT), but this generally fell between thirty and fifty minutes per student. The writer and an assistant carried out the individual testing as the principals of each school were anxious to complete testing in the shortest possible time. The writer administered the Visual Search Task, Reaction Time and the major proportion of the MFFT. The assistant gave the Porteus Mazes, Auditory Serial Recall, Trail-Making and a small number of the MFFTs, in that order.

Test battery

A description of each of the tests administered in Study 1 is given below. Procedure and scoring details are provided. Planning tests will be dealt with first, followed by the simultaneous, successive, and impulsivity measures.

a. Porteus Maze Test (PMT)

Developed as a test of "planfulness" in 1913, the PMT requires the completion of a visual-motor task in the proper sequence and prescribed fashion. Porteus conducted post-surgical examinations using the test

and demonstrated consistent and enduring performance losses in frontal lobe patients. The PMT discloses behavioral deficits in patients with frontal lobe or beginning diffuse cerebral disease, who show no specific sensory, perceptual or psychiatric disorders. Some questions have been raised regarding the usefulness of this test with severely mentally retarded and psychotic subjects, largely because of the difficulty experienced in communicating instructions. The test is usually classified as a nonverbal test involving ordering and planning (Lezak, 1976).

The Vineland revisions (1933, 1955, 1959) consist of twelve maze diagrams (eight for older children) in which the subject is directed to follow the path between guidelines without touching or crossing the lines. The subject begins at the letter "S" and terminates at the exit point. Mazes become progressively more difficult throughout the test. Standard presentation and scoring was used and test age was calculated for each subject. Examples of the mazes and directions appear in Appendix A.

b. Visual Search Task (VS)

Originally developed by Poppelreuter in 1917, the test was used by Teuber *et al.* (1949) to identify visual search deficits after cerebral lesion. Teuber (1964) found that frontal lesions caused a significant reduction in speed and efficiency of search, considerably more pronounced than when lesions were in the posterior cortex. The VS was considered to be a measure of planning. Teuber projected *fields* of forty-eight geometric, letter and numerical shapes onto a screen and inserted a *standard* shape into a circle in the centre of the field. Subjects were required to locate the duplicate of the standard, which was in the field. As Teuber's fields were unavailable, four *master fields* were constructed and to each master, four standards were assigned. These sixteen overhead

transparencies were used in a viewing apparatus which permitted accurate timing of the search for the duplicate of the standard. Two measurements were recorded, elapsed time for search and response, and elapsed search time. A description of the procedure and diagrams of the apparatus are in Appendix B, and copies of two fields are in Appendix C.

c. Trail-Making Test (TMT)

An original part of the Army Individual Test of General Mental Ability (1944) the TM was adopted by Armitage (1946), Reitan (1955) and Spreen and Geddes (1969) as a neurological screening test for brain damage. The test was reported by Armitage to measure planning, the ability to see a double relationship, and to shift from one stimulus sequence to another. No attempt has been made to identify deficient performance with brain lesion locations. Two forms exist, an Intermediate (ages 5 - 14), and an Adult level. Each is divided into Parts A and B. In Part A, the subject connects encircled numbers, distributed randomly over the page, in the correct numerical order. In Part B, letters and numbers are used and the subject draws lines, alternating between numbers and letters in the correct increasing sequence (for example, 1, a, 2, b, 3, c ...). The procedure outlined by Armitage (1946) was followed with the exception that both Intermediate and Adult forms were administered to all subjects. Total elapsed time to completion was recorded. Copies of each Part are in Appendix D and directions are provided.

d. Verbal Fluency Test (VF)

Thurstone and Thurstone (1941) defined Word Fluency as a clear primary mental ability, and French (1951) described a similar factor

loading highly on tests requiring recall of words with specific prefixes, first, first and last letters, or four-letter words beginning with a specific letter. Milner (1964) and McFie (1975) disregarded the notion of a primary mental ability, but demonstrated that these tests discriminated frontal lobe patients. Christensen (1974), in describing Luria's neurological tests for brain damaged patients, referred to the disposition of frontal lobe patients to perseverate on words, sentences and phrases. With this in mind, it was assumed that Thurstone's test may be a useful addition to the planning battery.

The VF test was adapted from Thurstone's Word Fluency tests and is divided into Parts 1 and 2, each prepared in an individual booklet form. Subjects were given practice in writing words containing the letter "A". Part 1 required subjects to write as many words beginning with "S" as possible in two minutes. Part 2 required subjects to write as many four-letter words beginning with "C" as possible in two minutes. Total number of words written (minus repeated words or foreign words not found in a standard English dictionary) were totalled and recorded. Appendix E contains instructions given to testees.

e. Planned Composition (PC)

Luria (1973b) observed that frontal lobe patients describe events impulsively and Christensen (1974) found similar difficulties involving perseverations and inability to maintain an overall plan in writing. It was assumed that the composition of a short essay would indicate the capacity to structure material and to plan if a satisfactory scoring procedure could be devised.

Diederich (1974) provided a procedure for rating high school essays

based upon a factor analytic study of composition grading conducted at the Educational Testing Service. Five dimensions were identified: Ideas, Usage and Structure, Organization and Analysis, Wording and Phrasing, and Individuality. A rating sheet, based on a Likert-type scale provided guidelines for high, medium and low standards in each dimension.

The PC rating used in Study 1 employed a scale similar to Diederich's which asked raters to evaluate Expression (thought given to the topic and ability to express ideas), Organization (underlying plan and logical sequence of material), Wording (correct and imaginative use of words), Mechanics (sentence structure, spelling and punctuation) and Individuality (creative and original composition of ideas).

Card 2 of the Thematic Apperception Test (Murray, 1943) (Country scene mural by Leon Kroll) was projected onto a screen for twenty minutes. Subjects were given a blank sheet of ruled paper and asked to write a one-page story about the picture. Each essay was transcribed onto a rating form and copies were distributed to four, Grade 8 Language Arts teachers for evaluation. Teachers were asked to read each story, then the descriptors for each dimension (for example, Expression, Organization) one at a time, then assess the essay by circling one number which best represented their evaluation of the essay in each dimension.

The total rating for each subject's Organization dimension was computed. Appendix F contains the instructions given to subjects, and examples of two completed, transcribed stories.

In addition to the five tests of planning described above, the following five marker tests drawn from the simultaneous-successive processing battery (Das *et al.*, 1975) were adminstered. These tests are

outlined below.

f. Figure Copying (FC)

Used as a test of developmental readiness at the Gesell Institute (Ilg and Ames, 1964), the Figure Copying test requires subjects to reproduce geometric figures. In the original series used by Das *et al.*, ten drawings of increasing difficulty were scored 0, 1 or 2 according to the accuracy of the reproduction based upon a scoring criteria (Leong, 1974). As the subjects in this study were older than previously tested children, six of the easier figures were deleted. Six were added from the Developmental Test of Visual Motor Integration (Beery, 1967) and two (the most difficult figures) were prepared and added by the researcher. This test usually loads on simultaneous processing. The diagrams and scoring criteria for each are in Appendix G.

g. Memory for Designs - Errors (MFD)

This second marker for simultaneous processing was originally derived from Graham and Kendall (1960). Fifteen figures were projected separately, each for a one second viewing period. Subjects were required to reproduce each figure which was scored 0, 1, 2, or 3 ("3" being poor) depending upon the correctness of the reproduction. The MFD test is set out in Appendix H.

h. Auditory Serial Recall (ASR)

The original test consisted of twenty-four lists of four words which were played over a tape recorder to minimize the possibility of spatial (simultaneous) arrangement. After each series was presented, the subjects

repeated as many words, in the correct order, as could be recalled. Twelve lists were comprised of unrelated words (for example, key, hot, cow, pen) and twelve were accoustically similar (for example, tap, mat, pan, cat).

An informal pilot with five eighth grade students indicated a ceiling effect, and hence the inappropriateness of the short test. The version used in this study included sixteen lists of words (eight paradigmatically similar and eight unrelated) prepared by this researcher, which began with a four-word series and progressed to a seven-word series. This test normally loads on successive processing. Number of responses recalled in the correct serial order for each trial was totalled and recorded. Appendix I contains the word list used in this study.

i. Visual Short Term Memory (VSTM)

The original marker test of successive processing involved the separate viewing of twenty, five-digit grids projected onto a screen for five seconds. When the slide was removed, subjects were required to read off color names from a grid for two seconds to preclude rehearsal. Upon removal of the color slide, subjects recorded as many digits as they could recall in their correct position, into an empty grid. The number of digits placed in their correct positions were totalled for the test and recorded. Appendix J contains the stimulus grids.

j. Digit Span - Forward (DS)

This test was abstracted directly from the Wechsler Intelligence Scale for Children (1974). Subjects were read lists of digits of increasing lengths (see Appendix K) and were required to recall and enter the

numbers in the correct order, onto a scoring form. The score was the maximum list length recalled correctly. This test loads on successive processing (Molloy, 1973; Cummins, 1973).

The last two tests described were included in the exploratory analyses dealing with the relationship between the coding, planning, and impulsivity measures.

k. <u>Matching Familiar Figures Test (MFFT)</u>

This test was developed by Kagan *et al.* as one measure of Reflection-Impulsivity and gives reliable results over time. The test involves the simultaneous presentation of a figure (for example, a rose, soldier, aeroplane) with eight facsimiles differing in one or more details. On each of the twelve items, the subject selects the alternative which exactly matches the standard. Time to first response, and number of errors overall are recorded. Close adherence to the directions supplied with the MFFT was maintained throughout the testing by the researcher and his assistant. Directions for the Adolescent/Adult MFFT are in Appendix L.

l. <u>Reaction Time (RT)</u>

As the MFFT involved the interaction of both speed and accuracy, the writer thought that a relationship may exist between impulsivity and simple reaction time. This test was added to the battery mainly through curiosity and used the Visual Search apparatus to take a simple reaction time. This was achieved by the following procedure: The researcher actuated a switch which lit the screen of the apparatus, and started an electronic timer. The testee was given instructions to depress the screen and turn

the light off immediately after it was illuminated. Five trials and one practice attempt were given and the subject's score was the total elapsed time for all trials.

Results

Research Question 1 was examined in Study 1 primarily using correlation and factor analysis, the aim of which was to produce the most simple factor structure to account for the coding and planning dimensions. Using principal component analysis, this objective can be achieved by varying the number of factors extracted, and the type of rotation performed.

In most cases, the most simple structure was achieved by extracting factors which had eigenvalues greater than 1.0, however, in a number of cases, an additional factor permitted more consistent explanations of the factor loadings. In previous research dealing with simultaneous and successive processing, Das and his co-workers found that orthogonal and oblique rotations did not produce significantly different factor structures. Both classes of rotation were performed on each set of data, though they were not always reported in tables.

The first set of analyses focussed on research Question 1 by examining the commonalities between the planning tests using data from the total Grade 8 sample. Orthogonal and oblique rotations were performed. The second group of analyses examined the presence of the simultaneous and successive dimensions using the same groups of subjects. In the third set of analyses, the planning and coding tests were correlated and factor analyzed. Orthogonal and oblique solutions were obtained using data from the total Grade 8 sample. The independence of the planning and the coding factors was examined further using an analysis of variance procedure. A double median split was performed on the one hundred and four subjects on the basis of their

simultaneous and successive factor scores and four groups were defined. Five *post hoc* 2 x 2 analyses of variance were performed using planning factor scores, and the raw scores from the Visual Search Task, Trail-Making Test, Verbal Fluency and Planned Composition.

Finally, the relationship between planning, coding and personality variables was explored. Intercorrelations and a factor analysis with an orthogonal solution provided insights into the various dimensions.

The planning tests

The means and standard deviations of the five planning tests can be seen in Table 3 and the correlations between the tests in Table 4. An examination of Table 4 shows that the Porteus Maze Test does not correlate significantly with any other test, and the organization dimension of the Planned Composition reached significance with the Visual Search Task only ($p<0.01$, $df=102$, one-tailed test). The correlation matrix was submitted to a principal component analysis and two factors, with eigenvalues greater than 1.0 were rotated according to an orthogonal (Varimax) and oblique (Promax) criterion.

The trends demonstrated in Table 5 show a commonality between the Trail-Making Test, Visual Search, Verbal Fluency and Planned Composition to some extent, and these tests define Factor I. The Porteus Maze Test alone defines Factor II. As the Porteus Maze Test did not correlate significantly with any other planning test, three explanations might be considered: 1. Planning is not a unitary dimension; or 2. The Mazes may be more accurately interpreted in coding process terms; or 3. The Mazes might measure some aptitude other than coding or planning.

Exploratory analyses, using male and female subject data separately were performed out of curiosity. These analyses are reported in Appendix M.

TABLE 3

Means and Standard Deviations of Five Planning Tests for Males, Females and Total Sample

Variable	Males*		Females*		Total Sample**	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Porteus Maze Test	14.83	1.73	14.62	1.54	14.72	1.64
Trail-Making Test	126.58	24.63	124.79	34.98	125.68	30.26
Visual Search	75.68	25.41	70.24	20.48	72.96	23.23
Verbal Fluency	25.87	7.70	29.62	8.78	27.74	8.47
Planned Composition	18.25	3.99	16.94	3.89	17.60	3.99

* n=52
** n=104

TABLE 4

Intercorrelations between Planning Tests for the Total Grade Eight Sample (N=104)

	PMT	TMT	VS	VF	PC
Porteus Maze Test (PMT)	1.000				
Trail-Making Test (TMT)	-.063	1.000			
Visual Search (VS)	-.033	.360	1.000		
Verbal Fluency (VF)	-.007	-.274	-.280	1.000	
Planned Composition (PC)	-.048	.099	.247	-.158	1.000

TABLE 5

Orthogonal (Varimax) and Oblique (Promax) Rotations of Two Factors
Principal Components Analysis of Five Planning Tests for the Total Grade 8 Sample (N=104)[1]

Variable	Orthogonal Factors			Oblique Factors		
	I	II	h^2	I	II	h^2
Porteus Maze Test	-029	976	954	037	979	954
Trail-Making Test	689	-051	477	687	-036	477
Visual Search	759	-029	576	758	-013	576
Verbal Fluency	-668	-154	470	-680	-170	470
Planned Composition	481	-178	263	470	-168	263
Variance	1.729	1.012	2.741	1.727	1.014	2.741
% of Total Variance	34.585	20.242	54.827	34.544	20.283	54.827

1 Decimals omitted

The simultaneous-successive marker tests

The means and standard deviations of the five marker tests of simultaneous-successive processing can be seen in Table 6 and the correlations between tests in Table 7. The correlations were submitted to a principal component analysis, and two factors with eigenvalues greater than 1.0 were rotated according to a Varimax criterion. Previous research by Das and his colleagues suggested that oblique rotations have not yielded more simple, or significantly different factor structures to those found by orthogonal rotation.

The factor structure shown in Table 8 conforms to previous findings (for example, Das *et al.*, 1975; Jarman and Das, 1977) with Auditory Serial Recall, Digit Span and Visual Short-Term Memory defining Factor I (successive processing) and Figure Copying and Memory for Designs defining Factor II (simultaneous processing). The loading of VSTM on Factor I is lower than desired though the correlations between VSTM, ASR and DS are significant at the 0.01 level of significance.

The coding and planning tests taken together

The relationship between five coding (simultaneous-successive) and five planning tests were explored using two procedures: factor analysis; and analysis of variance based upon a double median split of simultaneous-successive factor scores which enabled differences between four groups to be studied on the various planning tests.

The correlations among the simultaneous-successive tests were presented in Table 7, and among the planning tests in Table 4. Table 9 contains the intercorrelations, which were submitted to principal component analysis and four factors were rotated to an orthogonal (Varimax)

TABLE 6

Means and Standard Deviations of Five Simultaneous-Successive Tests for Males, Females and Total Sample

	Males*		Females*		Total Sample**	
Variable	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Figure Copying	15.12	5.12	14.75	4.52	14.93	4.83
Memory for Designs	1.19	1.65	2.48	2.91	1.84	2.45
Auditory Serial Recall	53.48	14.34	51.13	11.59	52.31	13.09
Digit Span	6.58	1.20	6.71	1.12	6.64	1.16
Visual Short-Term Memory	58.67	13.17	59.38	12.08	59.03	12.64

* n=52
** n=104

TABLE 7

Intercorrelations between Simultaneous-Successive Marker Tests for the Total Grade 8 Sample (N=104)

	FC	MFD	ASR	DS	VSTM
Figure Copying (FC)	1.000				
Memory for Designs (MFD)	-.335	1.000			
Auditory Serial Recall (ASR)	.009	-.105	1.000		
Digit Span (DS)	.049	-.088	.595	1.000	
Visual Short-Term Memory (VSTM)	.057	.007	. 231	.169	1.000

TABLE 8

Principal Component Analysis with Varimax Rotation of Simultaneous-Successive Marker Tests for Total Grade 8 Sample (N=104)[1]

Variable	Factor		
	Successive	Simultaneous	h^2
Figure Copying	-012	-819	671
Memory for Designs	-070	813	666
Auditory Serial Recall	870	-041	758
Digit Span	843	-066	715
Visual Short-Term Memory	485	009	235
Variance	1.707	1.338	3.045
% of Total Variance	34.150	26.761	60.911

1 Decimals omitted

TABLE 9

Intercorrelations of Simultaneous-Successive, and Planning Tests for the Total Grade 8 Sample (N=104)

	FC	MFD	ASR	DS	VSTM	PMT	TMT	VS	VF	PC
Figure Copying (FC)	1.000									
Memory for Designs (MFD)	-.335	1.000								
Auditory Serial Recall (ASR)	.009	-.105	1.000							
Digit Span (DS)	.049	-.088	.595	1.000						
Visual Short-Term Memory (VSTM)	.057	.007	.231	.169	1.000					
Porteus Maze Test (PMT)	.163	-.103	.022	.036	.132	1.000				
Trail-Making Test (TMT)	-.065	.240	-.076	-.145	-.099	-.063	1.000			
Visual Search (VS)	-.269	.146	-.105	-.168	-.086	-.033	.360	1.000		
Verbal Fluency (VF)	.214	-.203	.266	.265	-.001	-.007	-.274	-.280	1.000	
Planned Composition (PC)	-.194	.057	-.113	-.218	-.066	-.048	.099	.247	-.158	1.000

and oblique (Promax) criterion (Table 10). Only three eigenvalues (2.429, 1.451, 1.139) were found to be greater than 1.0, but a fourth factor (eigenvalue of 0.992) was also extracted to produce a more simple structure and account for a greater percentage of total variance. Four factors were justified according to criteria suggested by Carroll (1978) and Thurstone (1947).

Factor I was defined by Auditory Serial Recall, Digit Span and a minor loading on Verbal Fluency. It might be named as the successive factor, though Visual Short-Term Memory is minimally involved. Factor II is defined by the planning tests: TMT, VS, PC and to a lesser extent by VF. This factor accomodates the planning tests with the exception of the Porteus Maze Test. Figure Copying and Memory for Design loaded heavily on Factor III with minor loading on Verbal Fluency and Porteus Mazes defining the simultaneous processing dimension. The fourth factor is defined by the Porteus Mazes Test and Visual Short-Term Memory and might represent a dimension of spatial visualization. Additional exploratory analyses were performed on male and female data and these are described more fully in Appendix M.

The loadings of Verbal Fluency, Porteus Mazes and Visual Short-Term Memory require some comment. First, the emergence of the VF on Factors I, II, and III suggests that the test involves not only planning but also the interaction of both coding processes. Secondly, it is of some interest that the PMT and VSTM aligned themselves on a separate dimension. An examination of Table 9 shows that VSTM correlated significantly with ASR (at the 0.01 level) and DS (at the 0.05 level), anticipated from previous research, but not with the PMT. In fact, the PMT did not correlate significantly with any test. It might be assumed that the PMT stands alone

TABLE 10

Orthogonal (Varimax) and Oblique (Promax) Rotations of Four Factors following Principal Component Analysis, for the Total Grade 8 Sample (N=104) [1]

Variable	Orthogonal Factors					Oblique Factors				
	I	II	III	IV	h^2	I	II	III	IV	h^2
Figure Copying	-077	-252	673	217	569	-137	-188	645	251	569
Memory for Designs	-119	037	-814	062	682	-098	-099	-840	013	682
Auditory Serial Recall	887	-009	033	094	796	928	160	041	089	796
Digit Span	835	-160	014	080	729	846	-017	-006	069	729
Visual Short-Term Memory	263	-160	-169	682	588	266	-140	-216	663	588
Porteus Maze Test	-066	061	346	705	625	-049	115	354	729	625
Trail-Making Test	-080	613	-190	083	425	036	628	-087	091	425
Visual Search	-030	795	-139	-011	653	119	841	002	006	653
Verbal Fluency	405	-397	360	-294	538	336	-310	312	-287	538
Planned Composition	-096	596	061	-195	407	004	638	175	-171	407
Variance	1.757	1.641	1.453	1.159	6.011	1.760	1.658	1.431	1.162	6.011
% of Total Variance	17.6	16.4	14.5	11.6	60.1	17.6	16.6	14.3	11.6	60.1

[1] Decimals omitted

in terms of the processes it measures, though, on the surface it seems to involve some aspects of visualization.

The Porteus Maze loadings are curious for there is little in the literature to account for the present findings. Vernon (1965) and MacArthur (1973) give no indication of any process which might be involved, and recently, Spitz and DeRisi (1978) based their research on the assumption that the Porteus test was a measure of logical and strategic thinking for which foresight was an important element.

Milner (1964) and Cory (1971) found differences in the results of the Porteus and other similar maze tests. Milner declared that the Porteus Maze Test did not measure planning, but the ability to follow directions, perhaps a task which draws upon successive processing using visual stimuli. Jarman (1978b), in proposing a task analysis chart for classifying tests under the simultaneous-successive rubric, identified PMT as a conceptual task requiring simultaneous processing with successive output. The affiliations of the Porteus Mazes remain unresolved.

Does one's proficiency in simultaneous or successive processing affect planning? This question addresses the matter of the independence of planning, and the coding processes inferred by the information-integration model and Luria's approach to brain systems. An analysis of variance method, using simultaneous and successive factor scores as classification variables, and planning test scores as "dependent" measures is an appropriate and conservative test of dependency without implying causation.

Factor scores were generated for each subject for the simultaneous-successive, and planning factors based upon the total grade 8 analysis and the sample was divided into four groups on the basis of median splits

of the simultaneous-successive factor scores. The composition of the cells was allowed to reflect the correlation between the coding factors (that is, r=0.000), essentially describing orthogonality.

Subjects' scores (planning factor scores, and raw scores for the TMT, VS, VF and PC) were entered into the appropriate cells, and the differences between the groups were examined using two-way analysis of variance. The means for the groups and the F-ratios for the main and interaction effects are found in Table 11.

A significant main effect for the Visual Search task was found. This reveals that individuals high on the simultaneous dimension (being able to integrate whole patterns) will perform more successfully on the Visual Search task. This is understandable in view of the task demand of rapid search of the field to locate a specific shape amongst others. To obtain a *gestalt* of a field and extract one element from it, would seem to be a more efficient strategy than a systematic "reading" (left to right, top to bottom) search strategy. The lack of other main, or interaction effects provides reasonable evidence that the planning tests, in general, measure a dimension which is independent of coding processes.

Coding, planning and Reflection-Impulsivity

The means and standard deviations of the Reflection-Impulsivity measures and the Reaction Time for males, females and the total sample can be seen in Table 12, and the correlations between these and the coding and planning tests is presented in Table 13. These correlations were submitted to a principal component analysis, and five factors with eigenvalues greater than 1.0 were rotated according to a Varimax criterion. The solution is given in Table 14.

TABLE 11

Means and F-Ratios of Simultaneous (Sim) and Successive (Succ) Processing Groups on Planning Factor Scores and Planning Test Raw Scores

Variable	Means				F-Ratios		
	Hi Sim Hi Succ (N=25)	Hi Sim Lo Succ (N=27)	Lo Sim Hi Succ (N=26)	Lo Sim Lo Succ (N=26)	Successive	Simultaneous	Interaction
Planning Factor Scores	101.87	103.56	96.39	98.11	0.34	3.44	0.00
Trail-Making Test	122.21	135.82	121.15	123.05	1.71	1.36	0.97
Visual Search	74.99	84.01	67.75	67.74	1.86	9.08*	0.47
Verbal Fluency	26.56	26.11	31.96	26.35	3.49	3.02	2.53
Planned Composition	18.16	17.81	16.69	17.73	0.19	0.96	0.77

*$p>0.005$

TABLE 12

Means and Standard Deviations of Reflection-Impulsivity Measures and Reaction Time for Males, Females and Total Grade 8 Sample

Variable	Males*		Females*		Total Sample**	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Matching Familiar Figures Test (Errors)	23.65	7.42	24.56	7.83	24.12	7.64
Matching Familiar Figures Test (Time)	450.68	270.39	429.55	266.85	440.11	268.83
Reaction Time	1.055	0.224	1.145	0.276	1.100	0.255

*n=52
**n=104

TABLE 13

Intercorrelations between Simultaneous-Successive, Planning, Reflection-Impulsivity, and Reaction Time Measures for the Total Grade 8 Sample[1]

	FC	MFD	ASR	DS	VSTM	PMT	TMT	VS	VF	PC	MFFE	MFFT	RT
Figure Copying (FC)	1000												
Memory for Designs (Errors)(MFD)	-335	1000											
Auditory Serial Recall (ASR)	009	-105	1000										
Digit Span (DS)	049	-088	595	1000									
Visual Short-Term Memory (VSTM)	057	007	231	169	1000								
Porteus Maze Test (PMT)	163	-103	022	036	132	1000							
Trail-Making Test (TMT)	-065	240	-076	-145	-099	-063	1000						
Visual Search (VS)	-269	146	-105	-168	-086	-033	360	1000					
Verbal Fluency (VF)	214	-203	266	265	-001	-007	-274	-280	1000				
Planned Composition (PC)	-194	057	-113	-218	-066	-048	099	247	-158	1000			
Matching Familiar Figures Test (Errors) (MFFE)	-200	207	-037	-176	-023	-255	102	134	-157	176	1000		
Matching Familiar Figures Test (Time) (MFFT)	-013	-043	-103	-012	-038	218	019	199	022	019	-611	1000	
Reaction Time (RT)	-103	312	-144	-012	073	050	-043	059	-140	-000	038	103	1000

1 Decimals omitted

TABLE 14

Principal Component Analysis with Varimax Rotation of Simultaneous-Successive, Planning, Reflection-Impulsivity and Reaction-Time Measures (N=104)[1]

Variable	Factor					
	I	II	III	IV	V	h^2
Figure Copying	-354	056	-152	-539	344	560
Memory for Designs	183	-129	-023	746	-058	611
Auditory Serial Recall	-035	-075	876	-111	097	796
Digit Span	-214	099	823	024	060	737
Visual Short-Term Memory	-055	-149	298	113	713	636
Porteus Maze Test	-012	349	-073	-113	652	565
Trail-Making Test	691	-032	-028	-002	028	480
Visual Search	769	143	-017	134	-072	636
Verbal Fluency	-503	133	346	-256	-264	526
Planned Composition	486	-087	-153	-020	-110	279
Matching Familiar Figures Test (Errors)	190	-840	-087	148	-096	780
Matching Familiar Figures Test (Time to First Response)	127	900	-041	078	005	834
Reaction Time	-180	105	-166	759	193	684
Variance	1.852	1.752	1.743	1.573	1.203	8.124
% of Total Variance	14.248	13.473	13.411	12.101	9.256	62.488

1 Decimals omitted

Factor I is defined by the TMT, VS, VF and PC and represents the planning factor. Factor II isolated the Matching Familiar Figures Test measures and also contains a minor loading on the Porteus Mazes. Factor III loadings mainly comprise Auditory Serial Recall, Digit Span and Verbal Fluency while Factor IV is defined by Reaction Time, Figure Copying and Memory for Designs, and might be called the simultaneous factor. The very high loading of the RT was unexpected though Table 13 shows a significant correlation with Memory for Designs at the 0.005 level. This finding might be explained by asserting that RT is a very basic measure of simultaneous processing, involving an all-at-once stimulus presentation (visually and auditorily). These stimuli are encoded simultaneously. As this is the first time such a result has been found, substantiation may be required. Factor V shows the separation of the VSTM and the PMT.

Summary

A number of findings may be usefully summarized at this point. In general, the results confirm the theoretical relationship expected between the simultaneous and successive tests (Table 8). The relationship between the original five planning tests differed from the expected structure in one aspect, namely, that the Porteus Maze Test did not share commonality with the other tests (Table 5) but loaded highly with the Visual Short-Term Memory (Table 10).

The relation between the coding and planning tests also showed some variation, though the overall result was consistent with the theoretical prediction. A simultaneous, successive and planning factor was apparent. However, the Verbal Fluency test spread loadings to the successive and simultaneous factors in addition to the planning factor. The relative

independence of the coding and planning dimensions is shown by the analysis of variance using groups defined by a double median split of the coding factor scores (Table 11). Only the Visual Search test showed a significant main effect, with simultaneous processing, suggesting that subjects high on simultaneous integration found the Search task easier than other subjects.

The personality dimension of Reflection-Impulsivity loaded onto a single factor (Table 14) though a number of singificant correlations were found with other tests, notable simultaneous markers (Table 13). An unexpected, though perhaps spurious result in the factor analysis of all thirteen measures was the relationship between simple reaction time and the simultaneous tests. Some verification of this finding may be required before it could be asserted that reaction time is a major indicator of simultaneous processing.

CHAPTER V

STUDY 2:METHOD AND RESULTS

Method

Introduction

A general planning factor, consistent with theoretical expectations was found in Study 1 using the Grade 8 sample. Planning in this sense was defined by the commonality between four tests: Trail-Making, Visual Search, Organization demonstrated in essay-writing (Planned Composition), and to a certain degree Verbal Fluency. The planning factor was found to be orthogonal to the two coding processes of simultaneous and successive synthesis though correlations between individual planning and simultaneous-successive tests were found.

Previous research (for example, Das, 1972; Jarman, 1978d) showed that the factor structures obtained using simultaneous and successive tests with mentally retarded and nonretarded subjects are similar, though differences in absolute performanee of each group were apparant. Study 2 was conducted using retarded and nonretarded groups to confirm that similar factor structures emerge when planning tests are included with the coding battery. In addition, it was anticipated that an overall deficit in test performance would appear, implying that mental retardates not only perform more poorly than nonretarded subjects on the coding tests, but also show a significant decrement in planning.

Subjects

Volunteers between seventeen and fifty-seven years of age were sought for two groups: 1. nonretarded adults; and 2. educable mentally retarded adults. Normal, adult subjects were solicited by friends of the researcher for Study 2. Though no procedures were undertaken to

ensure a random or stratified selection of subjects, males and females were drawn from a wide range of unskilled, skilled, semi-professional and professional employment situations with a tendency towards the unskilled end of the career continuum. Sixty-six normals (35 males and 31 females) were included in the sample. Four were excluded: two as a result of missing data due to apparatus malfunction; and two who reported childhood accidents in which there was severe head-injury, though no current disability was apparent. The mean age of this sample was 27.8 years (standard deviation = 9.70).

The educable mentally retarded (EMR) sample was collected from clients attending two rehabilitation centres for adults in Edmonton, Alberta. Subjects were classified by agency administrators as EMR and had intelligence quotients (IQ) between 68 and 95. Forty-six subjects (22 males and 24 females) comprised the EMR sample, two were excluded due to abnormal testing behavior. The mean age of this group was 25.4 (standard deviation = 8.41) and the mean IQ was 78.6 (standard deviation = 7.26).

Procedure

The four tests which defined the planning factor in Study 1 (Visual Search, Trail-Making, Verbal Fluency and Planned Composition) were selected for administration in Study 2. In addition, Figure Copying and Memory for Designs comprised the marker tests for simultaneous processing and Auditory Serial Recall and Digit Span were selected as markers for successive processing. All tests were administered individually to each subject by the researcher.

Testing of the normal group was conducted in the Laboratory of the

Centre for the Study of Mental Retardation, and in the homes of a number of the subjects. Under these latter conditions, optimal testing conditions were not always possible, however, a quiet area which could be darkened for the Visual Search test was usually available. These conditions should be remembered when considering the results of this sample. Approximately forty minutes testing time was required for each subject and tests were administered in the following order: Figure Copying, Digit Span, Verbal Fluency, Trail-Making Test, Planned Composition, Memory for Designs, Auditory Serial Recall, and Visual Search. This sequence was chosen so that interest could be maintained throughout the session and to avoid giving marker tests for the separate coding processes together.

Testing of the mentally retarded adult group was conducted in a room available at each of the rehabilitation centres. For the most part, these satisfied minimum requirements for noise level, isolation from interruption and could be dimmed for the Visual Search task. All testing was conducted by the researcher in the order given above.

Test battery

The test battery below was described more fully in Chapter 4. Some changes were necessary to the testing procedures of two measures to accomodate the EMR subject's writing skills and slower comprehension of test directions. Procedures and scoring details are provided below. Planning tests will be described first, followed by the simultaneous, and successive measures.

a. Visual Search Task (VS)

The sixteen overhead transparencies described in Study 1 were used. Only one timer was attached to the viewing apparatus as the correlation between the Search, and Response Time was 0.974 and the former was considered to be the most appropriate measure. One other change was made, namely, a second practice transparency was given to the mentally retarded group as it was obvious from the outset that an additional sample and explanation was necessary for satisfactory comprehension of the instructions. Total elapsed time for search of the sixteen trials was recorded.

b. Trail-Making Test (TMT)

This test was administered as it was described in Study 1. The procedure outlined by Armitage (1946) was followed with one alteration, namely, that both Intermediate and Adult forms were given to all subjects. Total elapsed time for completion of the four trials was recorded.

c. Verbal Fluency Test (VF)

This test is an adaptation, in two parts, of Thurstone's Word Fluency as was described in Study 1. As with the Grade 8 subjects, the normal group was asked to read the directions on the cover of each booklet quietly and practice using the space provided. The EMR group was asked to follow while the tester read the directions out loud and to write words in the usual manner. It was thought that some EMRs might not be able to complete the test satisfactorly due to slow writing rather than poor word recall skills. This was not the case. Though they wrote fewer words overall, their test behavior was similar to the normal adult group. Total number of words written (minus repeated, nonsense or foreign words not found in a standard English dictionary) were totalled

and recorded.

d. Planned Composition (PC)

In Study 1, subjects were asked to look at a photograph and write a one-page story based upon the picture. It was anticipated that the EMR subjects would experience difficulty in writing, and may be overly conscious of spelling and script. To overcome these problems, Study 2 subjects were asked to tell, rather than write, a story about the picture.

Henry (1947) suggested that this task would permit evaluation of organizational complexity or the ability to mentally structure a story. As such, story telling in response to a stimulus such as the Thematic Apperception Test might reflect aspects of planning related to the manner in which subjects presented sequential verbal ideas.

Changing the format had positive and negative consequences. In the earlier study, the Grade 8 children were oriented towards a written task, similar to those which are assigned during the school year. Adults may not have this disposition as many had been some years out of school and employed in a non-scholastic occupation. However, being asked to tell a story may also be unusual for them, especially when requested by a relative stranger, in an unusual testing situation. Despite the drawbacks, the oral rather than written test was considered appropriate for administration because: 1. the mentally retarded sample might not be as severely prejudiced by an oral task; 2. it would involve less individual testing time; and 3. it appeared to maintain a planning orientation.

As in the previous study, Card 2 of the Thematic Apperception Test (Murray, 1943) was projected onto a screen but the subjects' stories were

tape recorded and transcribed onto rating forms similar to the Study 1 sheets. As loquaciousness varied greatly within, and between the groups, a 100-point scale was chosen over the original 7-point scale so that both normal and EMR stories could be evaluated together. Examples of two completed, transcribed stories for each group are given in Appendix F.

In addition to the four tests described above, the following four simultaneous and successive processing markers were administered.

e. Figure Copying (FC)

Subjects were required to copy the twelve geometric figures described in Study 1 and in Appendix H. Reproductions were scored 0, 1, or 2 ("0" being poor) depending upon the accuracy of the copy, and the total score was recorded. This test usually loads on the simultaneous factor.

f. Memory for Designs - Errors (MFD)

This second simultaneous marker test was comprised of fifteen geometric figures which subjects were asked to view for one second (projected onto a screen) and reproduce. Each was scored 3, 2, 1, or 0 ("3" being poor) depending upon the accuracy of the copy, and the total error score was recorded.

g. Auditory Serial Recall (ASR)

This test included sixteen lists of words (eight paradigmatically similar, and eight unrelated) which began with a four-word series and progressed to a seven-word series. Subjects were required to recall each

series in the correct serial order and were scored accordingly. Total words recalled in the correct serial position were totalled and recorded. This test usually loads on the successive factor.

h. Digit Span - Forward (DS)

This second successive marker was abstracted directly from the Wechsler Adult Intelligence Scale (1955). Lists of digits were read to subjects and they were required to recall each list in the correct serial order. The score was the maximum list length recalled correctly. A copy of the list is in Appendix K.

Results

Research Question 2 was examined using two procedures: 1. A confirmatory analysis examined the stability of the factor structure found in Study 1; and 2. a two-sample Hotelling T^2 test compared the differences found between the normal and EMR groups on the several variables.

Simultaneous and successive synthesis in normal and EMR groups

The means and standard deviations of the four simultaneous and successive marker tests for normals and EMR subjects are found in Table 15. The correlations between tests for the normal group are in Table 16. Significant correlations were found between Digit Span and Auditory Serial Recall ($p<0.001$, df=64, one-tailed test) and between Figure Copying and Memory for Designs ($p<0.05$, df=64, one-tailed test). This correlation matrix was submitted to principal component analysis and two factors with eigenvalues greater than 1.0 were rotated according to an orthogonal (Varimax) criterion. The trends shown in Table 17 confirm Factor I as the successive dimension, and Factor II as the simultaneous dimension.

Table 18 presents the correlations between the coding markers for the EMR sample. High correlations were found between Digit Span and Auditory Serial Recall (at the 0.001 level of significance) and between Figure Copying and Memory for Designs (also at the 0.001 level). This correlation matrix was submitted to principal component analysis and two factors with eigenvalues greater than 1.0 were rotated according to an othogonal (Varimax) criterion. Table 19 shows the simultaneous and successive processing factors with the respective loadings on FC and MFD, and DS and ASR. It is interesting to note that this two-factor

TABLE 15

Means and Standard Deviations for the Four Simultaneous and Successive Marker Tests for Normal Adults and Adult Educable Mentally Retarded Subjects

	Normals*		Educable Mentally Retarded**	
	Mean	Std. Dev.	Mean	Std. Dev.
Figure Copying	16.38	11.52	6.78	4.27
Memory for Designs	1.67	2.37	9.76	6.08
Auditory Serial Recall	56.89	11.52	28.85	14.58
Digit Span	7.08	1.59	5.00	1.12

* n=66
** n=46

TABLE 16

Intercorrelations between Simultaneous-Successive Marker Tests for the Normal, Adult Sample (N=66)

	FC	MFD	ASR	DS
Figure Copying (FC)	1.000			
Memory for Designs - Errors (MFD)	-.308	1.000		
Auditory Serial Recall (ASR)	-.136	.219	1.000	
Digit Span (DS)	-.193	.242	.622	1.000

TABLE 17

Principal Component Analysis with Varimax Rotation of Simultaneous-Successive Marker Tests for the Adult Normal Group (N=66)[1]

Variable	Factor		
	Successive	Simultaneous	h^2
Figure Copying	-035	838	703
Memory for Designs	193	-761	617
Auditory Serial Recall	900	-084	817
Digit Span	881	-162	802
Variance	1.624	1.315	2.939
% of Total Variance	40.605	32.864	73.469

[1] Decimals omitted

TABLE 18

Intercorrelations between Simultaneous-Successive Marker Tests for the Adult, Educable Mentally Retarded Sample (N=46)

	FC	MFD	ASR	DS
Figure Copying (FC)	1.000			
Memory for Designs - Errors (MFD)	-.609	1.000		
Auditory Serial Recall (ASR)	.044	.144	1.000	
Digit Span (DS)	.08-	.060	.761	1.000

TABLE 19

Principal Component Analysis with Varimax Rotation for the Simultaneous and Successive Marker Tests for the Adult, Educable Mentally Retarded Group (N=46)[1]

Variable	Factor		
	Successive	Simultaneous	h^2
Figure Copying	103	898	817
Memory for Designs - Errors	123	-895	817
Auditory Serial Recall	938	-051	882
Digit Span	936	031	877
Variance	1.789	1.604	3.393
% of Total Variance	44.715	40.107	84.823

[1] Decimals omitted

solution accounted for over 84% of the total variance. In contrast, a similar solution was obtained using the normal group (Table 17) but this accounted for only 73% of the total variance.

Tables 17 and 19 show the familiar factor structure which has appeared using groups of normal and retarded elementary school children (Das, Kirby and Jarman, 1975; Jarman, 1978d) and adolescents (Study 1). This trend confirms the stability of the coding strategies over a wide age range using the marker tests described herein.

Planning and coding in adult normals and EMRs

The means and standard deviations of the four planning tests for both normal and EMR samples are given in Table 20 and the correlations between tests for the normal group appear in Table 21. Table 21 shows significant correlations between FC and MFD ($p<0.005$, $df=64$, one-tailed test) and DS and ASR ($p<0.001$, $df=64$, one-tailed test) but also between TMT and MFD (at the 0.001 level) and TMT and FC (at the 0.0 level). Surprisingly, no significant correlations were found between any planning tests.

The correlation matrix in Table 21 was submitted to a principal component analysis and three eigenvalues were greater than 1.0, however, a fourth factor (with an eigenvalue of 0.969) was also extracted. These were rotated according to an orthogonal criterion (Varimax) and loadings are shown in Table 22.

Factor I is defined by MFD and TMT with a minor loading on FC and is most closely related to a simultaneous processing dimension. Factor II loads on ASR and DS and is interpreted as successive processing. Factor III is defined by FC, VS and VF and appears to have a spatial

TABLE 20

Means and Standard Deviations of Four Planning Tests
for the Normal Adults, and Adult Educable Mentally Retarded Group

Variable	Normals*		Educable Mentally Retarded **	
	Mean	Std. Dev.	Mean	Std. Dev.
Trail-Making Test	133.07	52.68	382.23	183.88
Visual Search	61.14	20.32	101.06	43.34
Verbal Fluency	31.62	9.23	13.04	5.50
Planned Composition	95.59	39.13	21.28	26.19

* n=66
** n=46

TABLE 21

Intercorrelations of Simultaneous-Successive and Planning Tests for the Normal Adult Group (N=66)

	FC	MFD	ASR	DS	TMT	VS	VF	PC
Figure Copying (FC)	1.000							
Memory for Designs (Errors) (MFD)	-.308	1.000						
Auditory Serial Recall (ASR)	-.136	.219	1.000					
Digit Span (DS)	-.193	.242	.622	1.000				
Trail-Making Test (TMT)	-.352	.654	.115	.005	1.000			
Visual Search (VS)	-.257	-.098	.116	.079	.101	1.000		
Verbal Fluency (VF)	.134	-.017	.022	.121	-.197	-.113	1.000	
Planned Composition (PC)	.072	-.041	.026	.088	-.026	.125	-.014	1.000

TABLE 22

Orthogonal (Varimax) Rotation of Four Factors following Principal Component Analysis for the Normal Adult Group (N=66)[1]

Variable	Factor				
	I	II	III	IV	h^2
Figure Copying	-407	-215	565	255	597
Memory for Designs - Errors	892	210	106	-021	851
Auditory Serial Recall	109	846	-065	006	732
Digit Span	072	895	008	052	809
Trail-Making Test	878	-040	-210	010	817
Visual Search	-163	167	-812	118	728
Verbal Fluency	-186	290	545	-056	419
Planned Composition	-011	057	-060	973	955
Variance	1.810	1.723	1.339	1.033	5.906
% of Total Variance	22.630	21.542	16.740	12.915	73.826

1 Decimals omitted

orientation. Factor IV is uniquely defined by the Planned Composition.

The PC should be mentioned at this point. Administration of this oral test did not produce satisfactory results. With few exceptions, both retarded and nonretarded subjects commented that they did not like having to tell a story out loud as they were poor at telling stories.

The written stories may have been easier for the Grade 8 children as this format conforms to the demand characteristics of their normal school situation. In contrast, the retarded and nonretarded adults were asked to relate a story into a tape recorder in the presence of a stranger, often an anxiety-provoking task for many people.

Evaluation of the transcribed essays by the raters also proved unsatisfactory. The EMR group and the normals were evaluated at the same time on the same scale. As the majority of the EMR subjects were unable to spontaneously generate a story (they mostly described the scene), their ratings were very low, producing a floor-effect. The lack of significant PC correlations was therefore not altogether unexpected and the measure in this study might be more closely aligned with a personality rather than a cognitive dimension.

As this analysis presented in Table 22 yielded somewhat unexpected results with the simultaneous and planning tests loading together, and with the questionable validity of the PC, a second analysis was performed which excluded the essay ratings. Three factors with eigenvalues greater than 1.0 were rotated according to a Varimax criterion. The loading shown in Table 23 parallels those in Table 22 with the PC removed, suggesting that the essay had little impact on the coding/planning dimensions.

Table 24 contains the correlation matrix derived from the EMR data.

TABLE 23

Orthogonal (Varimax) Rotation of Three Factors following Principal Component Analysis for the Normal Adult Group (N=66). Planned Composition test deleted

Variable	Factor[1]			
	I	II	III	h^2
Figure Copying	-453	-198	-536	532
Memory for Designs - Errors	889	203	121	846
Auditory Serial Recall	112	849	-068	738
Digit Span	076	895	010	808
Trail-Making Test	874	-044	-199	805
Visual Search	-159	175	-818	726
Verbal Fluency	-178	283	556	421
Variance	1.835	1.715	1.325	4.875
% of Total Variance	26.217	24.503	18.927	69.648

[1] Decimals omitted

TABLE 24

Intercorrelations of Simultaneous, Successive and Planning Tests for the Adult Educable Mentally Retarded Group (N=46)

	FC	MFD	ASR	DS	TMT	VS	VF	PC
Figure Copying (FC)	1.000							
Memory for Designs (Errors) (MFD)	-.609	1.000						
Auditory Serial Recall	.044	.144	1.000					
Digit Span (DS)	.086	.060	.761	1.000				
Trail-Making Test (TMT)	-.321	.332	.011	-.010	1.000			
Visual Search (VS)	-.312	.501	.127	-.026	.538	1.000		
Verbal Fluency (VF)	.224	-.192	.106	.335	-.496	-.321	1.000	
Planned Composition (PC)	.079	-.048	.182	.068	-.137	.078	.069	1.000

Significant correlations were found between: FC and MFD, TMT and VS; between MFD and TMT and VS; ASR and DS; VF and DS, VF and VS; and TMT and VS and VF. The PC did not correlate significantly with any other test. Intercorrelations were submitted to a principal component analysis and four factors were extracted (with eigenvalues of 2.578, 1.910, 1.031 and 0.973) and rotated according to an orthogonal criterion (Varimax).

Table 25 shows Factor I as being defined by TMT, VS and VF (the planning factor) Factor II by DS and ASR (successive processing), Factor III by FC and MFD (simultaneous processing) and Factor IV again, uniquely Planned Composition. An additional analysis was performed in which the PC variable was deleted. Three factors (with eigenvalues of 2.569, 1.875 and 0.995) were extracted and rotated according to a Varimax criterion. This solution (Table 26) conforms with the coding-planning paradigm showing the separate loadings of the planning tests, simultaneous and successive tests on different factors, except for the VS which shows a slight loading on the simultaneous factor. This is not surprising in light of the Grade 8 results in which VS had a significant main effect with simultaneous processing (Table 11).

Hotelling T^2 test was used to evaluate the significance of the difference between the normal and EMR group performance on the eight tests to ascertain whether specific or general deficits exist with respect to coding and planning. If EMRs showed limited deficits it would be anticipated that significant differences would only occur on certain variables. Alternatively, a general deficit would be exemplified by significant differences between the performance of the EMR and normal groups on all variables. Normal and EMR sample mean vectors were compared and found

TABLE 25

Orthogonal (Varimax) Rotation of Four Factors following Principal Component Analysis for the Adult Educable Mentally Retarded Group (N=46)[1]

Variable	Factor				
	I	II	III	IV	h^2
Figure Copying	-120	113	-871	073	791
Memory for Designs - Errors	213	123	869	003	816
Auditory Serial Recall	050	916	025	142	863
Digit Span	-138	939	-004	-041	902
Trail-Making Test	831	075	219	-162	769
Visual Search	651	116	434	215	672
Verbal Fluency	-805	263	-017	021	717
Planned Composition	-049	073	-042	976	961
Variance	1.854	1.843	1.752	1.052	6.492
% of Total Variance	23.064	23.034	21.905	13.151	81.154

1 Decimals omitted

TABLE 26

Orthogonal (Varimax) Rotation of Three Factors following Principal Component Analysis for the Educable Mentally Retarded Group (N=46). Planned Composition test deleted

Variable	Factor[1]			
	I	II	III	h^2
Figure Copying	-128	120	-873	793
Memory for Designs - Errors	223	127	866	815
Auditory Serial Recall	055	925	020	860
Digit Span	-134	931	-003	885
Trail-Making Test	833	053	212	741
Visual Search	658	139	420	629
Verbal Fluency	-803	270	-010	717
Variance	1.858	1.848	1.733	5.439
% of Total Variance	26.545	26.400	24.761	77.706

[1] Decimals omitted

to be significantly different ($p<0.001$, $df=8,103$). Individual test means were examined by multiple comparisons to check which variates led to the significant group differences.

Table 27 shows the variable means for both groups, the Hotelling T^2 value and the probability of population differences. The levels of significance all approach zero. It may be assumed that the EMR subjects exhibit significant coding and planning deficits of approximately the same order, suggesting an overall rather than specific cognitive deficit.

TABLE 27

Mean Vector Comparisons of Coding and Planning Tests for Normal and Educable Mentally Retarded Adults[1]

Variable	Group Means		T^2
	Nonretarded*	Retarded**	
Figure Copying	16.38	6.78	145.946
Memory for Designs	1.67	9.76	94.237
Auditory Serial Recall	56.89	28.85	126.534
Digit Span	7.08	5.00	79.005
Trail-Making Test	133.07	382.23	106.477
Visual Search	61.14	101.06	41.811
Verbal Fluency	31.62	13.04	146.773
Planned Composition	95.59	21.28	124.148

[1] All T^2 values are significant ($p<0.001$)

*n=66
**n=46

CHAPTER VI

CONCLUSIONS

This chapter is divided into two sections. The first gives a brief summary of the results and recounts the discussion of some limitations of the research which became apparent. The second section deals with implications and suggests where further research may be directed.

The Planning and Decision-Making unit of the Information-Integration model existed as a theoretical proposition derived from evidence presented by Luria (1966a, 1966b). His research demonstrated that patients with localized frontal lobe damage showed deficits in "planfulness" while coding mechanisms associated with other cortical areas remained intact. The relationship between frontal lobe damage and concommitant cognitive dysfunction was assumed to be an appropriate starting point from which to seek and establish an independent planning dimension in the Das model.

It was not possible to examine the performance of brain-damaged subjects on the coding and planning tests. Support for the status of planning in relation to coding is implied from the statistical relationship between selected tests. Theoretically, tests can be chosen because they discriminate between frontal and non-frontal lobe damaged patients; such tests should demonstrate commonality using non-brain-damaged samples. If tests involve different sensory modalities, and what might be regarded as different skills then, the commonality might imply that a similar process or strategy is implicated and that this might be called "planning". The information processing model developed by Das and his co-workers provided the functional and statistical framework upon which to base the research.

Study 1 confirmed the existence of separate simultaneous, successive

and planning factors, in accordance with the predicted structure using a normal adolescent sample. Study 2 used the same approach and provided evidence for the stability of the coding-planning relationship in retarded adults, and to a lesser extent, in a sample of non-retarded adults. The discovery of the planning dimension is significant if for no other reason than that it supports the notion that an executive mechanism which oversees and directs the coding of information might exist.

The significance of results often reflects the consideration and selection of the several tests used in the research. This has been an important consideration during the development of Das' model, notably because of the association between neuropsychological findings and the cognitive analogue.

The representation of planning was a second consideration when choosing tests for the research reported herein. One criterion for inclusion of different tests in the planning battery was that they appeared to involve different modalities or tap different reasoning abilities. The Trail-Making test and Visual Search are both spatial and time-oriented tasks while Verbal Fluency and especially Planned Composition draw to some extent on previous learning and have an educational bias. All planning tests correlated with standard intelligence test scores (TMT and VF with nonverbal IQ, and VS and PC with both verbal and nonverbal IQ's) though a relationship between formal education and one's ability to self-initiate strategies was not substantiated by a *post hoc* principal component analysis (not reported in Chapter IV). Six factors with eigenvalues greater than 1.0 were extracted and were named: Planning, Simultaneous Processing, Successive Processing, Personality (MFFT only), Visualization (Porteus Maze and VSTM) and School Achievement. This last factor had loadings on

verbal and nonverbal IQ and the Planned Composition only.

The Planned Composition is of interest for a number of reasons. This test provided an attempt at construct validation of planfulness since raters were asked to evaluate the essays on the degree of apparent organization and planfulness. While considerable subjectivity was involved in these evaluations, results of Study 1 provide fair evidence for concluding that planning was tested.

In Study 2, changes in Planned Composition were introduced: the PC was changed from a written to an oral test; and further, the samples of subjects were no longer school children. In study 1, the test loaded satisfactorily on the planning factor while in Study 2 it did not correlate significantly with any test. Two reasons might account for these results. First, there appeared to be a significant floor effect with the mentally retarded sample. Of these subjects, five were not only unable to generate a story, but were also incapable of describing the picture. In general, the characteristic EMR response was simply to indicate that three people were situated on a farm. Numerous near-zero ratings (out of 100) were given by the evaluators; but overall the ratings appear to be unreliable. Second, while it was obvious that EMRs had difficulty generating spontaneous stories, normal adult subjects also showed considerable reluctance and a lack of spontaneity. Many subjects, both EMRs and normals alike, expressed shyness and uneasiness with this format. Probably the changes made in the PC did not allow it to be used as an index of planning. This may have originated from the artificiality of the situation and unfamiliarity with experiences similar to the task demands of the PC. Such a loss or decline in the facility to perform tasks such as the PC may be similar to characteristics found in the cognition of the aged when performance drops

due to lack of use. Many subjects simply described the scene depicted on the photograph without telling a story. The test, however, shows potential as an indicator of planfulness among adolescent students and justifies further examination and development.

Whether the successive marker tests used in these studies truly represent the dimensional name requires some discussion. The administration of the entire coding battery (simultaneous and successive tests) together with the planning tests was not possible due to the time constraints. It was necessary to select marker tests which should adequately define the dimensions. In Study 2, VSTM was deleted from the battery. As a result, it might be argued that DS and ASR are simply measures of auditory short-term memory. Previous findings, however, have shown that DS and ASR consistently load on a factor which is orthogonal to the simultaneous dimension in the predicted manner (Das, Kirby and Jarman, 197 ; Molloy, 1973; Cummins, 1973). In addition, if only short-term memory was involved, it might be anticipated that DS and ASR would correlate with MFD (a short-term memory task). As the principal component analysis produced the expected factor structure it may be concluded that the tests selected in Study 2 were representative of the simultaneous and successive processing battery.

The results of the study reported herein have three significant aspects. First, the identification of a planning factor which has its foundation in neuropsychology lends support to the theoretical paradigm adopted by Das *et al.* (1975). The establishment of this dimension provides support for assumptions made regarding the association of the Planning and Decision-Making, to the Simultaneous-Successive processing units of the Information-Integration model.

With delineation of the three processing units and the inferential relationship to cortical regions, the way is open for validation of the relationship between Luria's systems of the brain and the cognitive approach upon which this research was based. The most profitable approach would be to isolate three diagnostic groups with predominantly left hemispherical damage in frontal, temporal, and occipital-parietal regions. It is anticipated that simultaneous processing would be beyond the capabilities of the occipital-parietal damage patients; successive processing would be beyond the capabilities of temporal lobe damaged subjects; and successful planning would be beyond the capabilites of frontally damaged subjects. Identification of the samples may be made through examination of Computed Tomography (CT) records which contain diagnoses related to frontal, temporal, parietal and occipital lobes. However, a number of problems are inherent in this strategy: 1. hemispherical localization is not provided on the CT records; 2. there appears to be an abundance of predominantly frontal diagnoses with few recognized posterior brain damage; and 3. damage which is recorded on CT records is not specific (for example, infarction, cortical atrophy). Certainly further developments in this area should yield much information and establish the validity of the Information-Integration model.

A second finding of Studies 1 and 2 is the continued stability of the simultaneous and successive factors. Previous research predominantly focussed on elementary school children under a variety of socio-economic and cultural settings. The current research demonstrated a similar factor structure in both adolescents and normals and retarded adult groups, showing that these coding processes are consistent across a wide age and ability range.

The relationship between the coding and planning dimension may need substantiation and clarification especially using normal adult groups (average age of 26). Planning was shown to be largely independent of coding processes in the adolescent student sample but associated with simultaneous synthesis in the adult group. If the relationship between tests is correct, it suggests that adults engage the simultaneous processing strategy when attempting the planning tasks used herein. Presently there is no evidence to support this shift between the ages of fourteen and twenty-six years.

Third, the stability of the simultaneous-successive processing in the mentally retarded group is consistent with previous research using retarded children. It is interesting that the EMR group also showed a factor structure using coding and planning tests which was similar to the adolescents and to a lesser extent, normal adults. The EMRs show a qualitative similarity to the normal adolescents but a lower level of performance in coding information.

One significant issue relating to coding and planning must be raised at this point, that is, whether simultaneous and successive synthesis can be separated from planning. Three orthogonal factors suggested that the processes involved are indeed distinct. However, this has not been reconciled with inferences drawn from the Das model, in particular, that the Planning and Decision-Making unit acts upon coded material and is responsible for the manner in which information is processed. This suggests that the coding and planning aspects of cognition may be related in a manner more complex than might be indicated by the orthogonality of the planning and coding factors. It appears that consideration of the demand characteristics of the planning tests used in these studies may be of some

relevance.

The Trail-Making, Visual Search, Verbal Fluency and Planned Composition tasks required subjects to engage appropriate coding mechanisms and initiate specific strategies for dealing with the integration of stored information. The degree to which planning or coding may be more influential under different conditions might be exemplified by observations made by subjects during the Visual Search task. When number or letter *standards* were used many subjects stated that the duplicate "jumped out from the screen". This possibly signifies the predominant use of simultaneous integration in recognizing familiar patterns. In contrast, geometric shape *standards* appeared to be more difficult to locate, requiring subjects' active search to locate the appropriate shapes.

Varying the task demands of the VS may lead to a differentiation of coding and planning. Changing test instructions may achieve a similar result in the VS and other tasks. In Table 10 the VF loaded on the simultaneous, successive and planning factors. By indicating a preferred strategy in the directions, the experimenter may effect the employment of predominately planning or coding behavior as indicated by a change in loadings on the several factors. For instance, the subjects may be asked to begin writing words commencing with "SA" until all known words are exhausted, then "SE", "SI" and so on. Asking for accoustically similar, or paradigmatically associated words might lead to different results. These changes in test procedure are speculative at this time, requiring some development and exploration.

It seems plausible that planning tests would correlate significantly with the coded dimension to which they have the greatest affiliation, or those which are most consistently engaged for successful completion.

More simply stated, if a planning test mainly involves integration of information via spatial relationships, it would correlate with simultaneous tests.

Pribram (1973) proposed a memory storage analogy (neural holograms) in which input at any moment is correlated not only with the configuration of excitation existing at any point, but also with electrical stimulation arriving from other parts of the brain. Memory is then imprinted with sensory information, reinforcement contingencies and intention based upon electrical interference. Hunt and Lansman (1975) proposed that information is held in store not as individual "bits" but as whole, organized units capable of carrying out behavioral sequences. The implication may be that information/processes may be stored in terms of holistic patterns which are more easily identified with simultaneous than successive synthesis and might also suggest that homogeneous measures (Jarman, 1978c, 1978d) of planning may not be easy to isolate.

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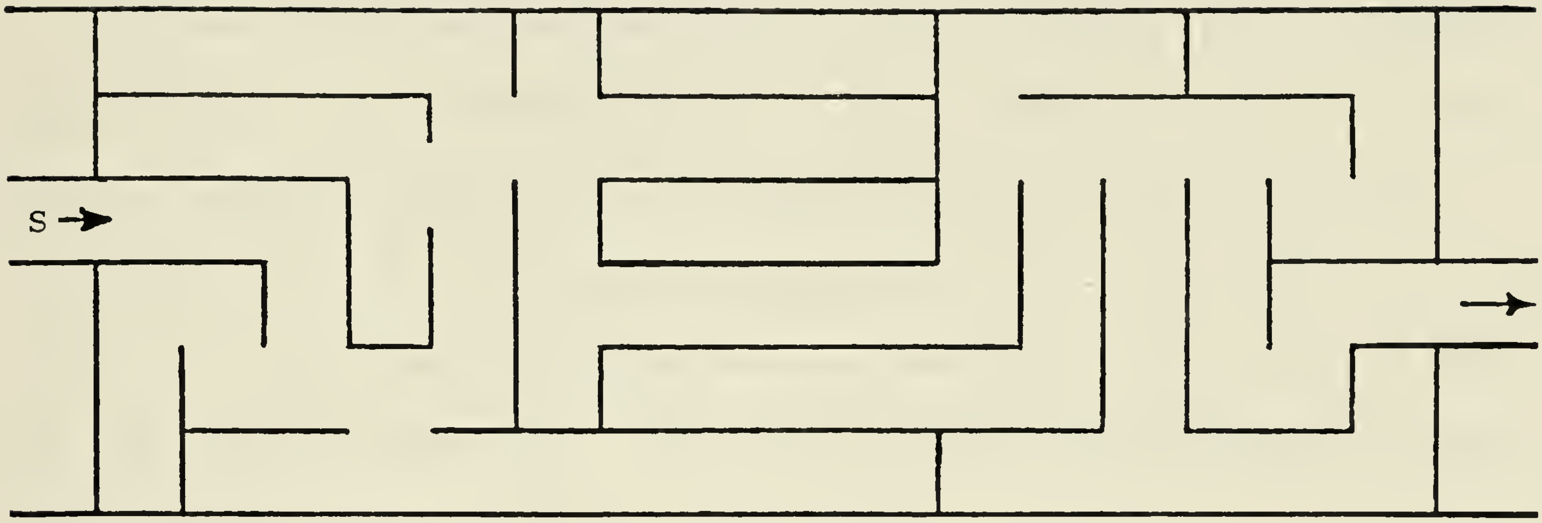
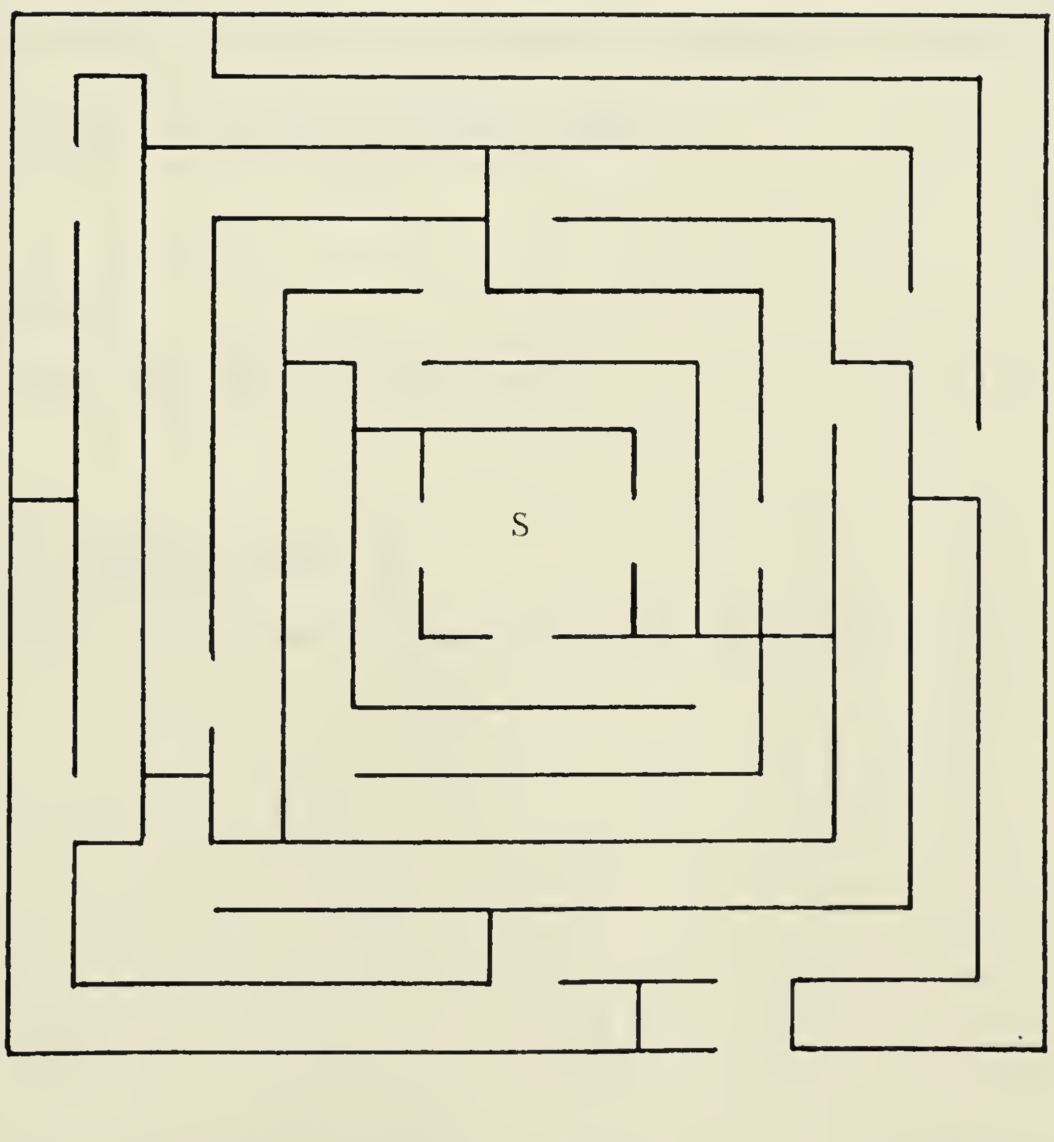
APPENDIX A

Examples of the Porteus Maze Test



PORTEUS TESTS — VINELAND REVISION YEAR VII



PORTEUS TESTS — VINELAND REVISION ADULT I

Directions for the Porteus Maze Test

Year VII:

"I want you to suppose that this is a maze in the form of a street map. All the lines are stone walls. You can imagine, if you like, that you are walking or driving a car in here (S) and you have to find your way out here (arrow). But you must be careful not to bump into any of the walls or go into any blocked streets, because if you do so you cannot turn around or back out. So if you go into a blind street, you must start all over again.

"This is not a speed test. You can stop anywhere as long as you like while you decide which way to go, but try not to lift the pencil off the paper until you are right outside the maze, and do not bump into any walls. Start as soon as you are ready."

Years VII, IX, X:

"Begin here and find your way out."

Years XI, XII, XIV and Adult I:

"Begin here in the center and find your way out."

APPENDIX B

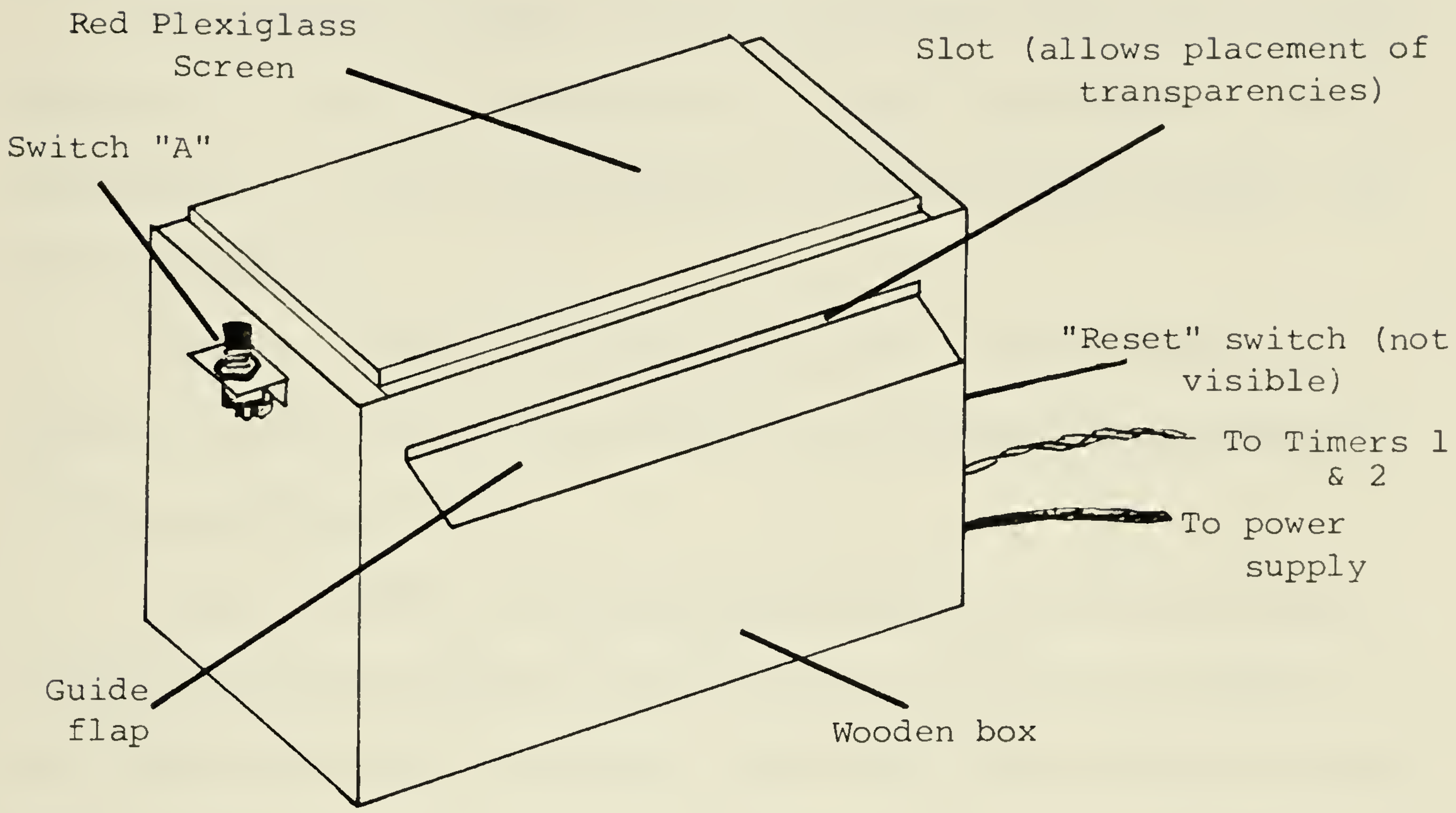
Description of the Visual Search Apparatus

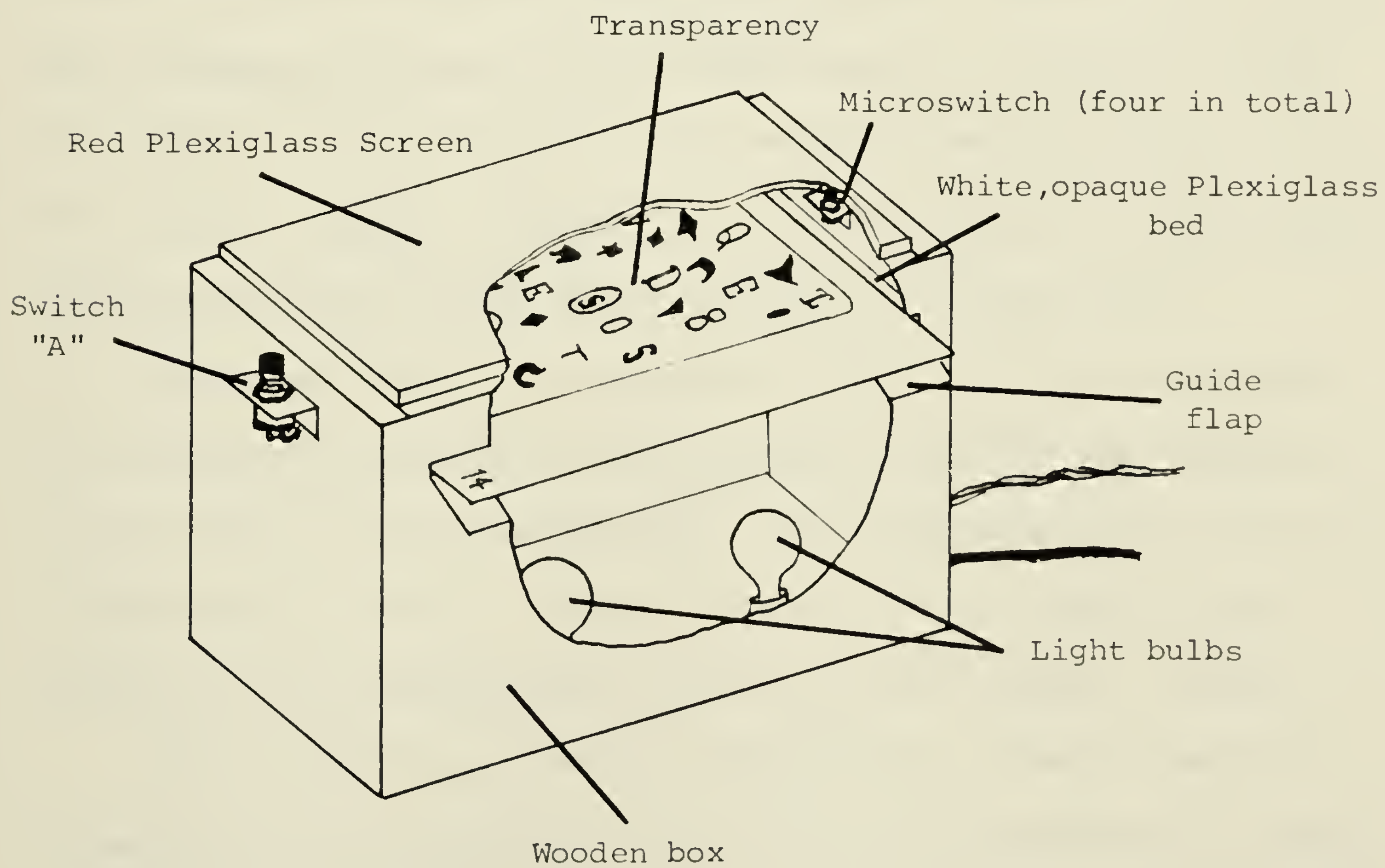
The Visual Search Apparatus consisted of two electronic timers (Lafayette, Model 54417-A) and a search box. This wooden box was 24 centimeters wide, 27 centimeters high, and 36 centimeters long. A red Plexiglass screen was mounted on top, 2 centimeters above a white, opaque Plexiglass bed, and supported by four microswitches and springs. A slot in one side of the box permitted placement of an overhead projector transparency onto the Plexiglass bed.

Depression of switch A on the front side activated timers 1 and 2, and simultaneously switched on lights below the opaque bed, thereby permitting the testee to view the transparency through the red screen. When switch A was released, timer 1 stopped, and a delay kept the lights illuminated for a further one second. This sequence enabled subjects to search the transparency and provided an elapsed search time (taken from depression of switch A and illumination of the transparency, to release of switch A).

Instruction required subjects to locate the duplicate of the standard shape found on the transparency, and to point to it by depressing the red screen. Pressing activated microswitches beneath and stopped timer 2. This provided an elapsed response time (taken from depression of switch A and illumination of the screen, to depression of the screen and switches B). A third switch (located at the back of the box) reset the timers simultaneously.

Diagrams of Visual Search apparatus
Closed and Cut-away views





Testing procedure

The procedure followed for administration of the Visual Search task was the same for each subject in Study 1 and Study 2. The directions to testees were played on a cassette tape recorder, and were as follows:

"This is a test of how quickly you can find one pattern in a group of similar ones. We're going to use this box and electronic timers attached to it.

"I have a number of transparencies which I am going to place inside the box and when you turn the light on, you'll be able to see them through the red screen. But first, let me explain how to work the box.

"When you push down on the black switch, and hold it down, the light will come on and the timers will start. There is one rule you must remember, you must hold the button down or the light will go off. Try it. Push the button down and then take your finger off it and see what happens. (Pause) So to keep searching the transparency you must keep your finger pressing down on the black switch.

"There is another way to turn the light off. You can do that by pressing down quickly on the red screen using the same finger you used to keep the black switch down. Let me demonstrate this for you. (Tester demonstrates) Now you try it. Turn the light on then switch it off by pushing down on the red screen quickly. (Pause)

"Let me show you one of the transparencies. (Tester inserts a a sample into the apparatus) This one has nine patterns on it which

are letter, numbers and geometric shapes, plus a circle in the middle. On all of the transparencies there will be a copy of the shape which appears in the circle, somewhere else in the field. Your task is to point to the shape in the field which is exactly the same as the pattern you will find in the circle. Do this as quickly as you can when the light comes on. The shape you will be looking for is always different on each transparency, and is the exactly the same as the one in the circle - it's never twisted around or distorted.

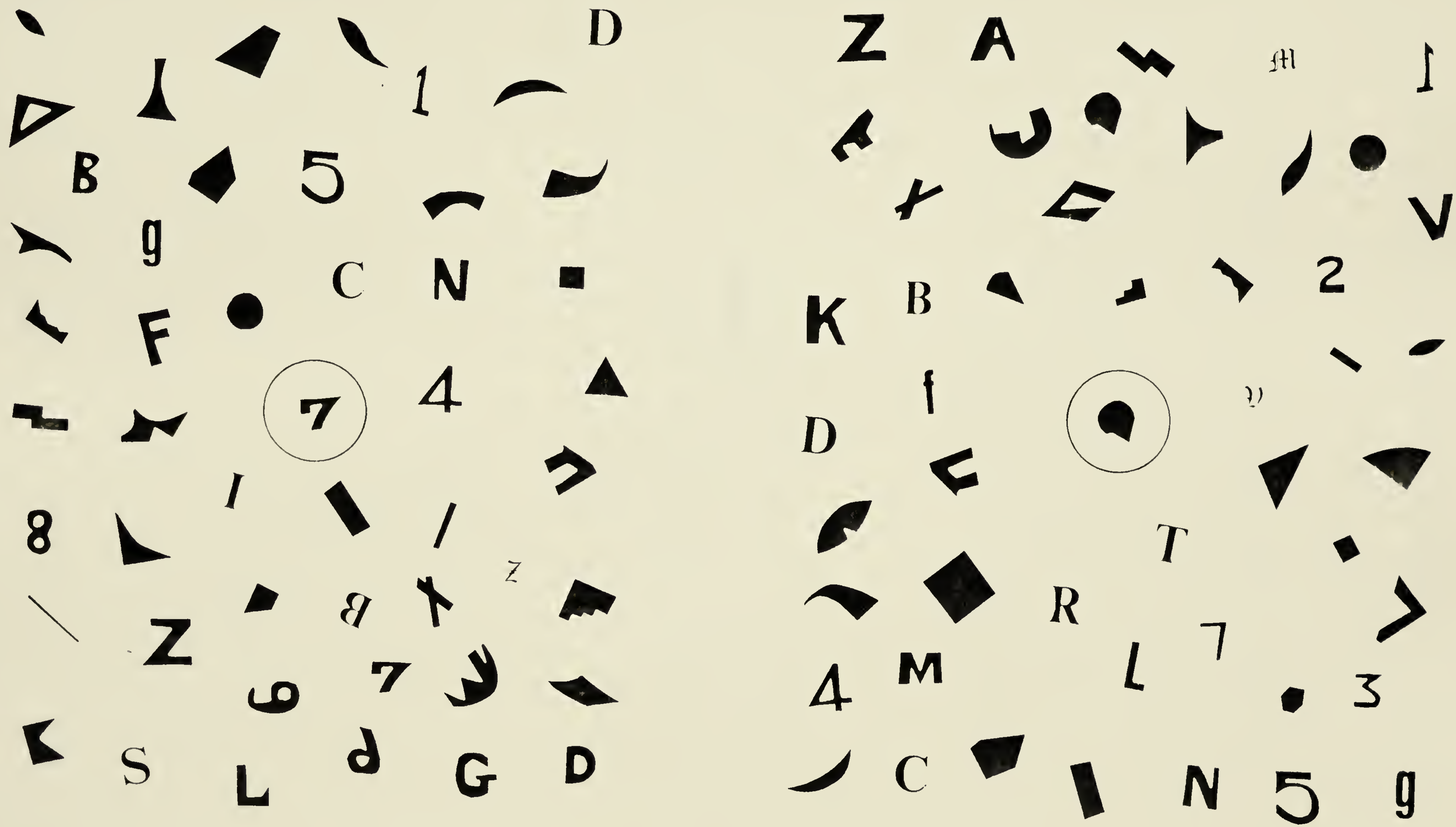
"Let us try a practice one, but first let me review the directions. When the transparency goes into the box, push down on the black switch and search for the copy of the shape you will find in the circle. Only when you have found the copy, lift your finger off the button and push down on the screen towards the copy. In effect you'll be pointing at the copy just below the screen.

"Are there any questions? (Tester inserts practice transparency into the apparatus)"

When the practice is complete, the tester reset the timers and placed the first trial slide into the box. Transparencies were presented in random order, and times were recorded after each trial. The correlation between the two measures (Search Time and Response Time) was high (r=0.974, significant at the 0.005 level).

APPENDIX C

Two Examples of Visual Search Transparencies (x 0.5)



APPENDIX D

Directions for the Trail-Making Test

Part A:

"This test is similar to the maze test that you just completed. Look here. In this test your task is to draw lines between the numbers on the page in the correct order - from 1 to 2, from 2 to 3, from 3 to 4 and so on, until the end is reached.

"If you realize you have made a mistake, go back and cross it out quickly (you do not have to erase the lines) and then go on in the correct way."

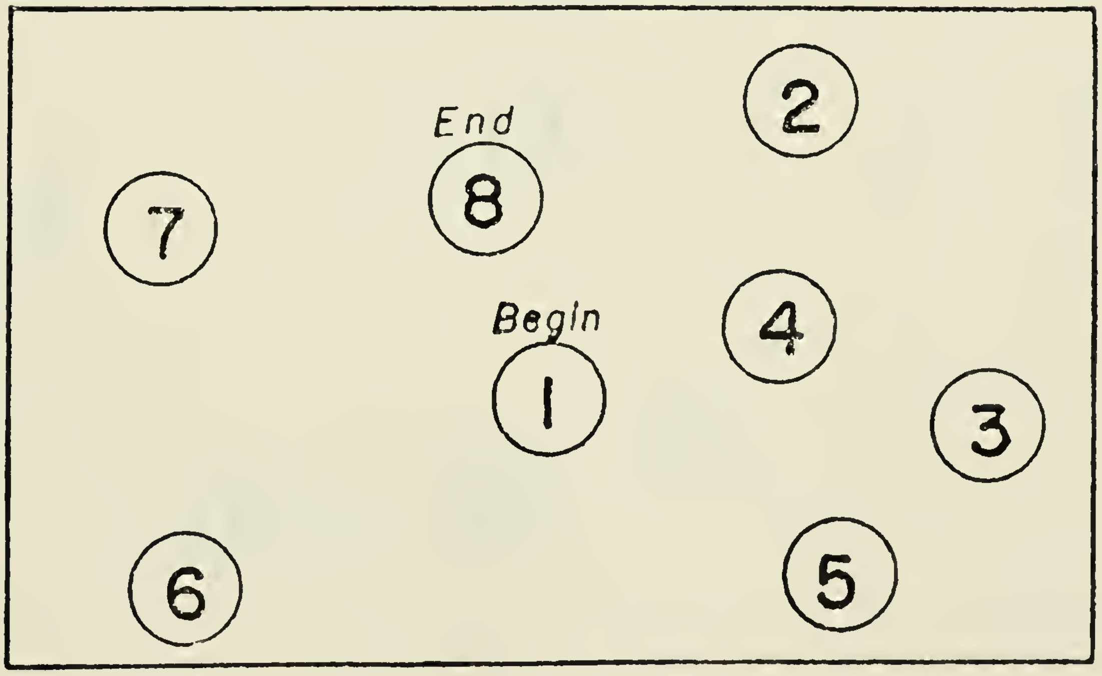
Part B:

"This part is similar to the other except there are both numbers and letters. In this test, your task is to draw a line from 1 to A, from A to 2, from 2 to B, from B to 3 and so on in this way until you get to the end. Work as quickly as you can. If you make an error, cross it out and go on quickly."

INTERMEDIATE FORM
TRAIL MAKING

Part A

SAMPLE




End
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5
4
13
6
Begin
7
1
14
2
8
10
3
9
11
12


15
17
21
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19
16
18
4
22
5
13
6
Begin
1
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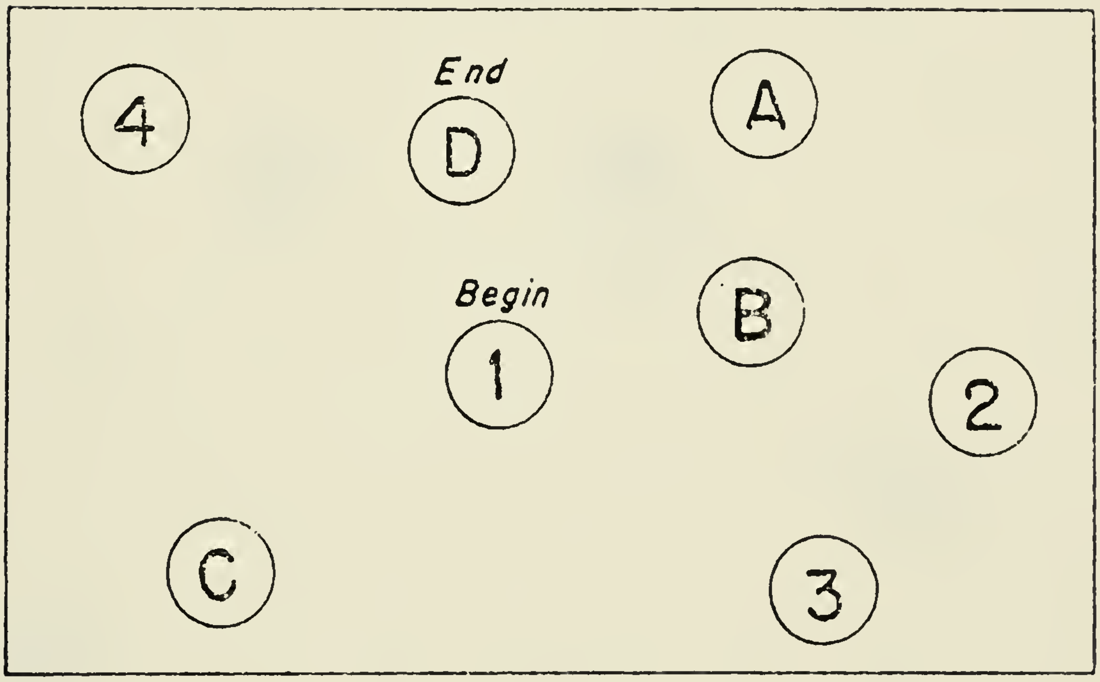
14
2
8
10
3
9
End
25
11
12
23

TRAIL MAKING

Part B

SAMPLE




End
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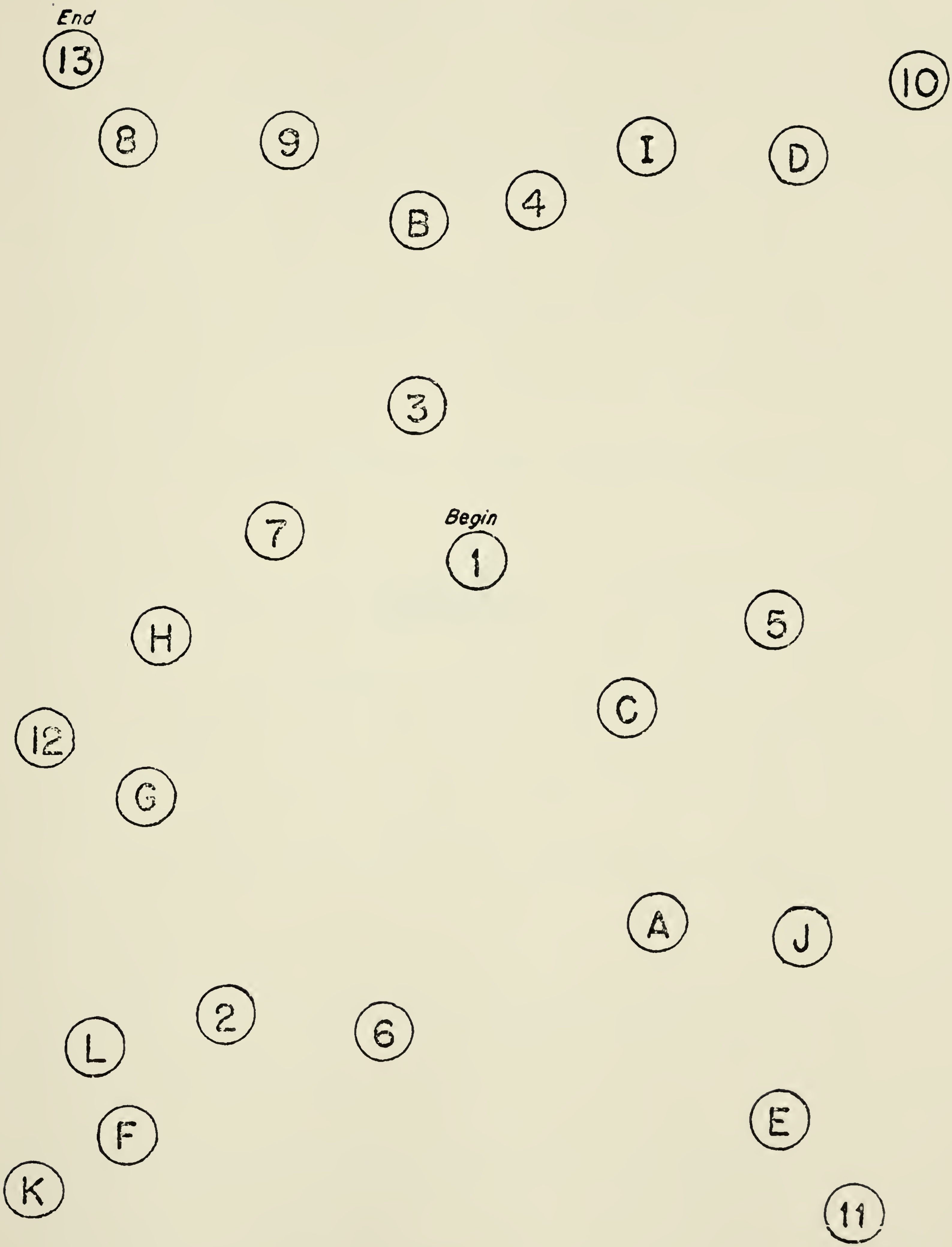
End
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Begin
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F
K
11

APPENDIX E

Instructions for the Verbal Fluency Test

a. "This is a test to find out how many words you can write. Try this practice test below. Write down as many words as you can which contain the letter "A". Any words will bo provided they are English words. Write only ONE word to a line as quickly as you can and remember that each word must contain the letter "A" at least once. (Space provided for the testee to write sixteen words, given thirty seconds)

"WAIT FOR THE SIGNAL BEFORE TURNING THE PAGE AND BEGINNING THE TEST ....

"Avoid using a word more than once, and avoid different forms of the word, for example: BAR, BARS. You have only TWO MINUTES, so work quickly when you are told to start. As there are only five lines on each page, you will have to flip over a page after you have finished each five words. Also, do not waste time by turning back to see which words you have already used.

"STOP HERE. DO NOT TURN OVER THE PAGE UNTIL YOU ARE ASKED TO DO SO ....

(Over the page)

"WRITE DOWN AS MANY WORDS AS YOU CAN BEGINNING WITH THE LETTER "S". No more than 5 words to a page."

b. "This test is similar to the one you have just finished.

"WAIT FOR THE SIGNAL BEFORE TUNNING THE PAGE AND STARTING THE TEST ....

"You only have TWO MINUTES for this test, so work as quickly as you can.

"As there are only THREE (3) lines to a page in this booklet, you will have to flip over a page after you have written each three words. Avoid wasting time by turning back to see which words you have already used.

"STOP HERE. DO NOT TURN OVER THE PAGE UNTIL YOU ARE ASKED TO DO SO ....

(Over the page)

"WRITE DOWN AS MANY FOUR-LETTER WORDS AS POSSIBLE BEGINNING WITH THE LETTER "C". No more than 3 words to a page."

APPENDIX F

Instructions for the Planned Composition

Instructions given to Study 1 subjects:

"This is a test to see how well you can write a short essay. All you have to do is think up, and write a story which would go with this picture. You will have twenty minutes to write your story and from experience we know that most people your age should be able to fill one page in that time. Please use the lined sheet you have been given.

"You can make up any kind of story you wish; it could be happy, sad, exciting or dull.

"Remember, you have twenty minutes. I will let you know when you have only five minutes left to write.

"Are there any questions?"

Instructions given to Study 2 subjects:

"In this test, I simply want you to make up a story that goes with this picture, and tell it to me. Your story can be as long as you want to make it. People seem to find it easier if they just start telling the story right from the beginning, but you can start anytime and finish anytime you wish."

Instructions to essay raters - Study 1

"We have attempted to make the rating of essays as easy as possible by typing the children's essays right onto the rating form, thereby removing the hazard of illegible handwriting and the trouble of using more than one sheet for each essay.

"All compositions were written by grade 8 students in regular classes,

and were based on the stimulus picture which is enclosed. The essays are reproduced exactly as written - spelling, punctuation and paragraphing have not been changed.

"Please rate each story using the scale provided at the bottom of each sheet. Draw a circle around the number rating which best represents your assessment of each dimension of the essay."

Instructions to essay raters - Study 2

"The stories reproduced here were told to the experimenter in response to the attached picture. Subjects were simply asked to think up a story that goes with the picture and to tell it into a tape-recorder.

"Please read each story and then rate it using a 100-point scale according to how well you think the story was planned. That is, it should have a sense of directed movement, be logically arranged and appear to have an underlying plan. If you think the story was very well planned you could rate it in the 80's or 90's. If it is poorly planned, somewhere in the 10's or 20's might be more accurate.

"Please use the whole scale, from zero to one hundred, and try to make discriminations between stories which seem to be at the same level."

Planned Composition Rating Scale

	1	2	3	4	5	6	7
EXPRESSION	Appears that thought has been given to the story; writer says what is meant; points relate to the topic; no padding.			Impression given that the writer does not fully understand what is meant; does not relate clearly; some padding & irrelevant material.			Hard to tell what the writer is saying; makes little sense; gives the impression of trying to get something on paper.
ORGANIZATION	Good starting point; has a sense of directed movement in story; appears to have an underlying plan; seems logically arranged.			Organization is standard and conventional; some trivial points given more importance than deserved; logic in progression is not always clear.			Starts anywhere and never gets anywhere; ideas are presented randomly with no apparent forethought.
WORDING	Use of uncommon words or words in unusual combinations which shows imagination; word experiments need not be successful 100% of time.			Uses common phrases or expressions; no apparent concern with the use of words.			Uses words carelessly; many mistakes in usage; unclear wording or childish vocabulary.
MECHANICS	No serious errors in sentence structure; punctuation correct; spelling consistent & appropriate for grade.			Some errors in structure but does not obscure meaning; violations in punctuation and spelling.			Serious errors in sentence structure making story difficult to understand; many punctuation errors makes story fragmented; many spelling mistakes.
INDIVIDUALITY	Unique or creative approach to material; unusual or original ideas; gives story a "twist".			Some originality shown; few interesting or unique aspects.			Not original at all; ideas are mundane, not creative and uninteresting.

Examples of two Grade 8 essays

Title: The crazy man, his wife and the maid

On a cool spring morning the Smith family had to harvest the ~~field~~ on a farm were the Smith family lived.

There was once a girl named Emma, who got married when she was 20. Her and her husband ~~in~~ bought a farm on the outskirts of New York. They bought a horse which they could barely afford so they took it to the races & won $50,000 so they got a maid. One day the man & the married woman got into a fight ~~He shave~~ because he shaved off his hair & joined religious group. After a while he & his wife made up & the wife felt sorry for him ~~so~~ because the people made fun of him, ~~s~~ and then it caught on every man & woman in the world shaved off their hair & he became famous and rich.

Title: Harvest

Once upon a time there was a man who knew his crop wouldn't grow. And the old wise lady said it would. By the man didn't believe her. But when he looked at the crop he realized that the crop was growing beautifully. As he was looking at the crop the old fat woman kept kodding her "You see" Then all the school children came to see the beautiful crop.

Then the man said thank you horses for helping me.

Examples of stories recounted by Retarded and Nonretarded Adults

Educable mentally retarded subjects' examples

1. What's it supposed to be? Something to do with farming. Well, they're putting something into the ground. They're plowing the ground. I don't know what the females are doing.

2. There she is, that beautiful girl going with this beautiful farmboy. They've been going together for six months and she doesn't know if she wants to marry him because he's working on a farm. He doesn't have much money, just a horse and a fairly big house and he's living with his mother. Should I keep going? No, I think I've finished.

Nonretarded subjects' examples

1. The mother and father were working hard to send the girl off to college. They were poor and the girl was really smart. She won all sorts of awards for the work she done. When she became famous, she came back and built new buildings for the parents who were getting old and made the rest of their lives really comfortable for them because of all the kindness they gave to her when she was a child.

2. The girl is going off to school but she's worried about her mum who looks ... pregnant in the picture there and she thinks she should really stay at home. Her days really are busy in the field and there's so much work to do with the horse and she knows that the mum will have to cook. Also, she's worried because she has an exam today but she'll

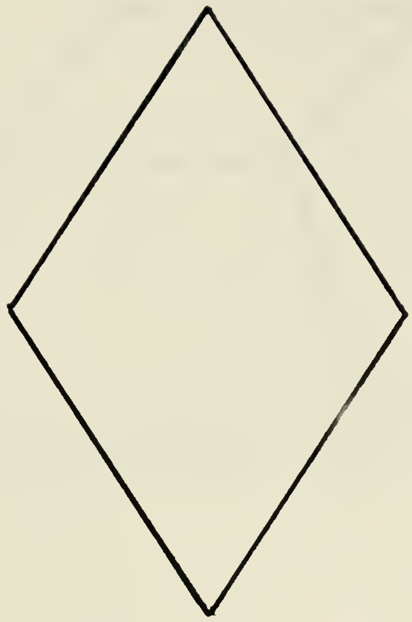
go anyway 'cause she usually likes school, generally. And she thinks her mum will make out OK.

They do have a permanent hand but he's helping the dad. And then she's probably thinking about maybe she doesn't like living on the farm. Maybe she'll move to the city soon but she's really not sure when she can do it, or get enough money to do it.

APPENDIX G

Figure Copying

1.



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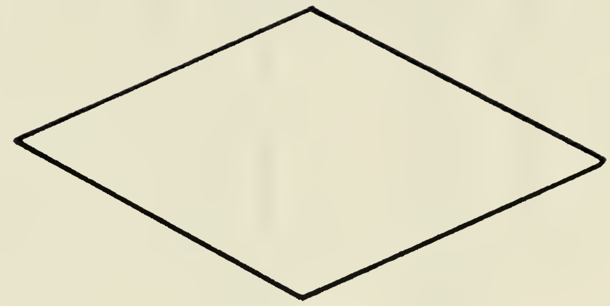

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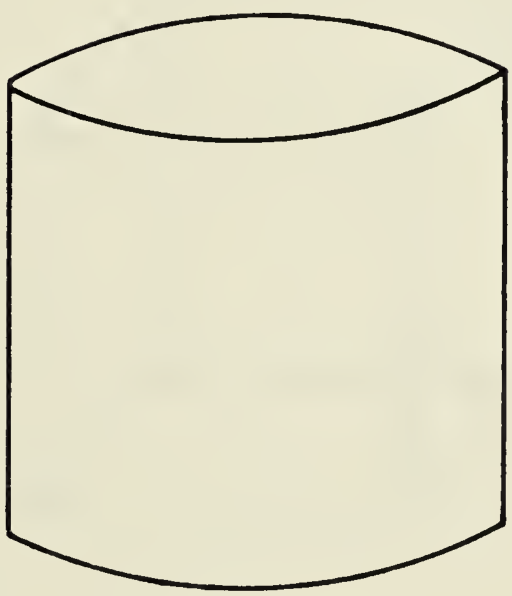

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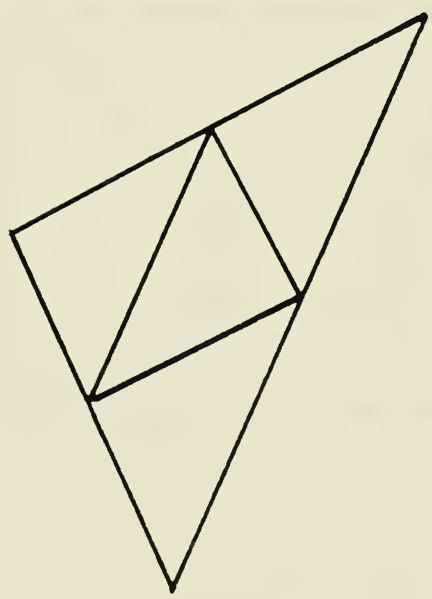

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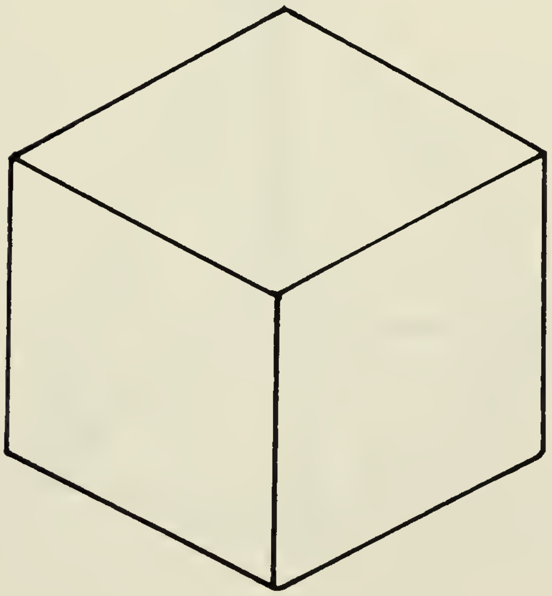

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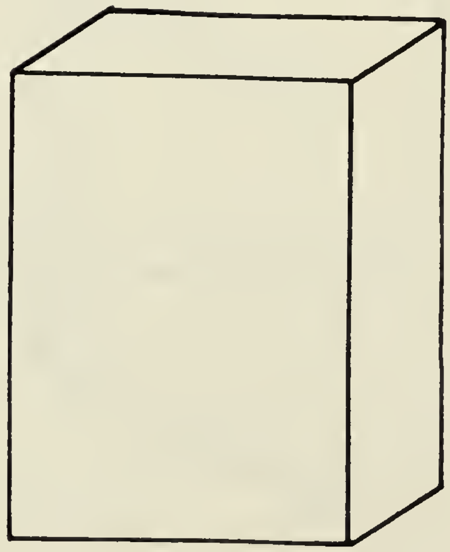

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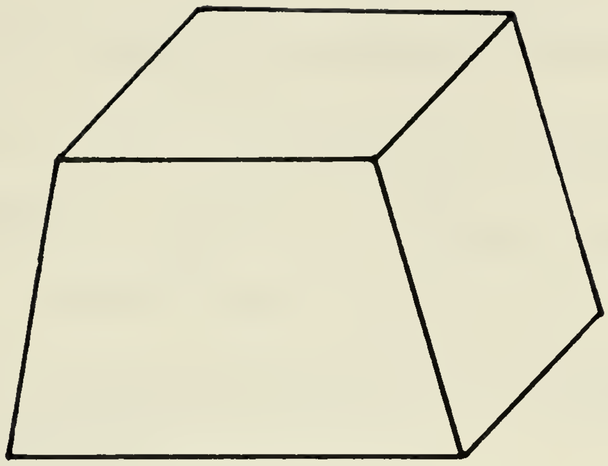

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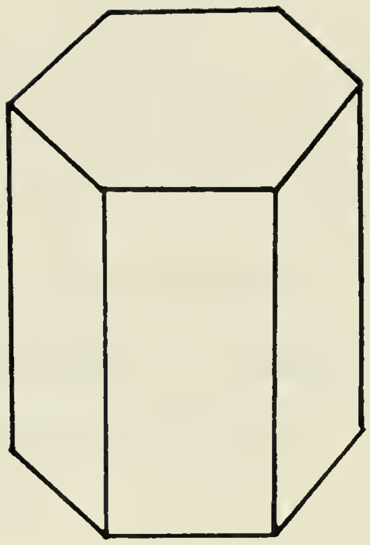

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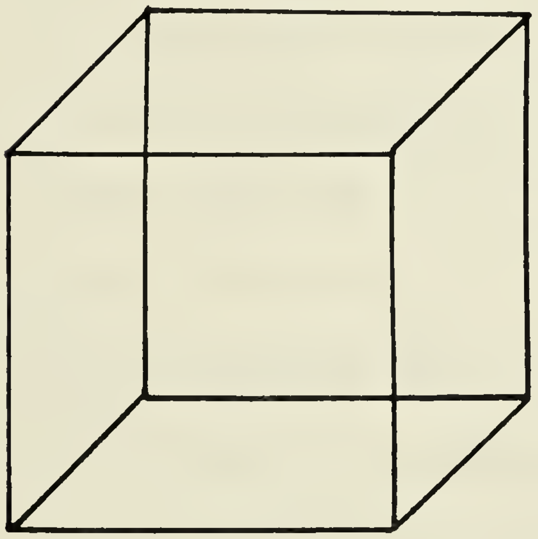

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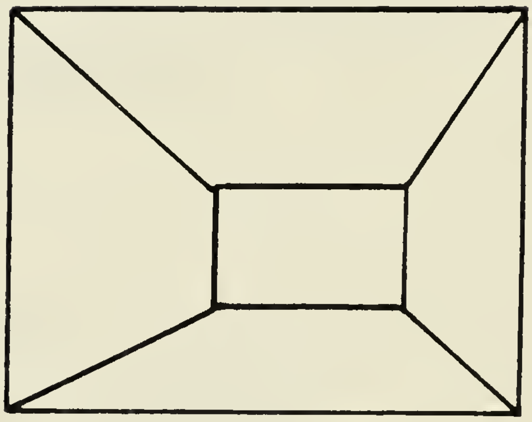

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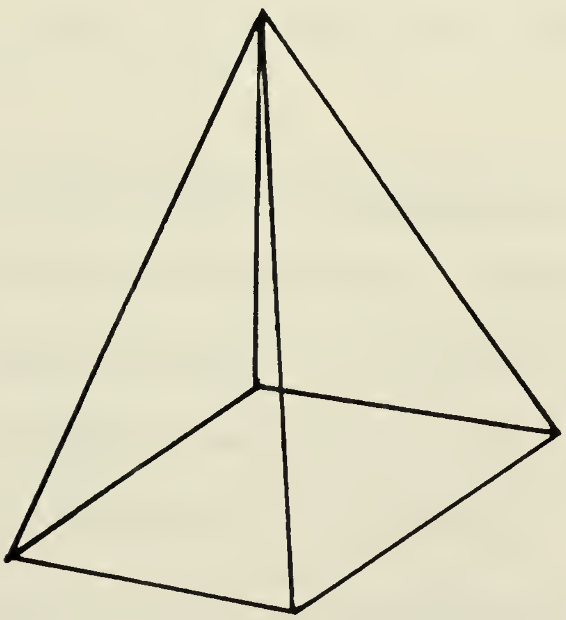

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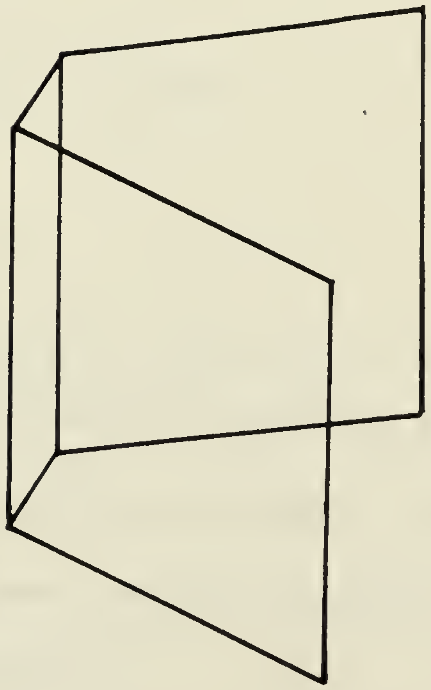


Guidelines for administering and scoring the Figure Copying Test

The subject is required to make an exact, free-hand copy of twelve shapes: a vertical diamond; a horizontal diamond; a cylinder; tilted triangles; a cuboid; an enclosed box; a trapezoid; an octahedron; a necker cube; a tapered box; a pyramid; and a stylized open book. Drawings are scored according to accuracy of shape rather than absolute size. The following principles apply:

For all drawings

1. The drawing must generally maintain the proper perspective
2. Drawings where applicable should be symmetrical
3. Angles should not be rounded
4. Figures should not be rotated
5. Angles should be equal, when applicable
6. Slight bowing or irregularity of lines is permitted
7. Lines should meet approximately, but small gaps or extensions are acceptable
8. When two attempts are made, the worst is scored

Scoring principles for individual figures

Scoring of each figure involves some limited flexibility. In general, some principles are considerd more important than others and are more stringently enforced. In the following table of standards, criteria are given in order of importance. Where the same numbers are given for two criteria, they are considered equally important.

1. Vertical Diamond

    1. No 'kite' shapes

    1. Horizontal opposing corners

    2. Four good corners

    3. Only slight 'dog-ears' allowed

    4. Both acute angles must be 60° or less

2. Horizontal Diamond

    1. No obvious 'kites'

    1. Opposing corners

    2. Four good corners

    2. Horizontal axis between 170° and 190°

    3. Both acute angles 60° or less

3. Cylinder

    1. Diameters should be approximately equal to the height

    2. Diameters of the base and top should be approximately equal

    2. The base and the top lines should be curved

4. Tilted Triangles

    1. Two triangles

    2. Right outer side sloped 100° or more

    3. Two corners of inner triangle clearly touch near medians of outer triangle, and the third must be close.

    3. Left outer angle approximately 90°

5. Cuboid

    1. Proper perspective must be preserved as in the specimen
    2. There should be three approximately equal diamonds
    3. All lines should be approximately equal (i.e. lengths, widths and heights

6. Enclosed Box

    1. Proper perspective must be maintained as in the specimen
    1. Figure must be almost half as high as it is wide
    2. Acute angles of parallelogram should be between 30° and 45°

7. Trapezoid

    1. Proper perspective should be preserved as in the specimen
    2. Parallelograms should have angles of approximately 45°

8. Octahedron

    1. Hexagon should have approximately equal sides
    2. Vertical rectangle should be bounded by two, near equal parallelograms.
    3. Left and right extreme angles of the hexagon should be near 90°

9. Necker Cube

    1. Correct number of parts
    1. Correct orientation
    1. No evidence of confusion

10. Tapered Box

    1. No confusion or distortion

2. Inner form clearly shifted to the right and down

3. Outer form a parallelogram

3. Inner form a horizontal rectangle

11. Pyramid

1. Figure is balanced around the vertical

1. No confusion or distortion

2. Base of figure is a diamond

2. All triangles are near isosles

12. Stylized Open Book

1. Two, mirror-image parallelograms with the acute angles near 75°

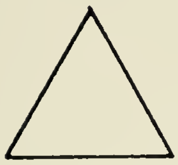
1. No confusion or distortion

2. Thin parallelogram should have acute angles between 30° and 45°

APPENDIX H

Memory-for-Design Test (MFD)

1



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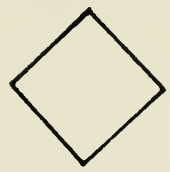

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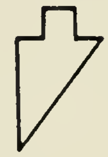

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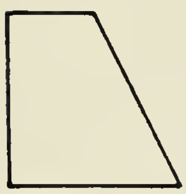

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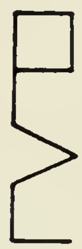

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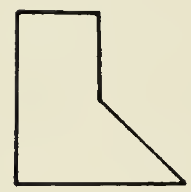

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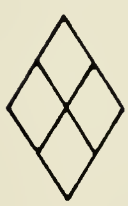

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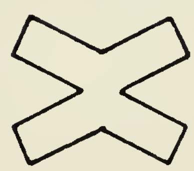

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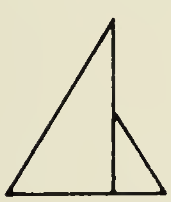

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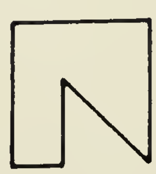

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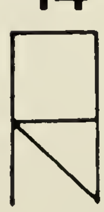

15

APPENDIX I

Auditory Serial Recall

1. tall, long, big, huge
2. high, tall, fat, big
3. day, cow, wall, bar
4. key, few, hot, book
5. book, bar, wall, hot, mat
6. wide, tall, large, huge broad
7. long, big, great, wide, fat
8. few, pen, hot, wall, bar
9. key, hot, cow, pen, wall, book
10. wide, large, big, high, tall, vast
11. long, big, fat, great, large, huge
12. pen, wall, book, key, cow, hot
13. high, fat, huge, wide, long, large, broad
14. day, key, cow, bar, wall, few, hot
15. great, high, tall, long, big, broad, fat
16. cow, day, bar, wall, few, mat, key

APPENDIX J

Visual Short-Term Memory

Example:	Read as:	Example:	Read as:
9 8 4 5 1	8 4 5 9 1	9 6 3 1 5	6 3 1 9 5

(1)	2 4 9 7 1	(2)	7 2 3 9 6	(3)	7 5 2 9 4	(4)	4 8 9 3 1
(5)	5 4 8 1 6	(6)	9 7 5 3 1	(7)	3 5 6 1 8	(8)	7 3 9 8 4
(9)	3 8 6 9 4	(10)	5 3 6 1 9	(11)	6 3 2 9 5	(12)	2 3 5 9 6
(13)	8 1 6 5 3	(14)	1 3 5 8 9	(15)	2 4 5 8 1	(16)	8 3 6 5 1
		(17)	1 5 6 3 8	(18)	5 9 2 3 6		

APPENDIX K

Digit Span

Study 1

3:	3 8 6
	6 1 2
4:	3 4 1 7
	6 1 5 8
5:	8 4 2 3 9
	5 2 1 8 6
6:	3 8 9 1 7 4
	7 9 6 4 8 3
7:	5 1 7 4 2 3 8
	9 8 5 2 1 6 3
8:	1 6 4 5 9 7 6 3
	2 9 7 6 3 1 5 4
9:	5 3 8 7 1 2 4 6 9
	4 2 6 9 1 7 8 3 5

Study 2

3:	5 8 2
	6 9 4
4:	6 4 3 9
	7 2 8 6
5:	4 2 7 3 1
	7 5 8 3 6
6:	6 1 9 4 7 3
	3 9 2 4 8 7
7:	5 9 1 7 4 2 8
	4 1 7 9 3 8 6
8:	5 8 1 9 2 6 4 7
	3 8 2 9 5 1 7 4
9:	2 7 5 8 6 2 5 8 4
	7 1 3 9 4 2 5 6 8

APPENDIX L

Directions for Matching Familiar Figures
Adolescent/Adult Set

"I am going to show you a picture of a familiar item and then some pictures that look like it. You will have to point to the picture on this bottom page (point) that is just like the one on this top page (point). Let's do some for practice." E shows practice items and S selects the correct item. "Now we are going to do some that are a bit harder. You will see a picture on top and eight pictures on the bottom. Find the one that is just like the one on top and point to it."

E will record latency to the first response to the first decimal[1], total number of trials for each item and the order in which the errors are made. If S is correct, E will indicate this to him. If wrong E will say, "No, that is not the right one. Find the one that is just like this one (point)." Continue to code responses (not times) until S makes a maximum of eight errors or gets the item correct. If incorrect E will show the right answer.

The test should be set up in a notebook. It is necessary to have a stand to place the book on so that both the stimulus and the alternatives are clearly visible to the S at the same time. The two pages should be practically at right angles to one another.

[1] This is a departure from the original instructions which specify timing to the half-second.

APPENDIX M

Exploratory analyses performed separately on male, and female data in Study 1

The analyses reported herein are *post hoc* examinations of the data. The results given in the body of the thesis represent a more adequate basis upon which predictions can be made due the larger sample size. By dividing the total sample into males and females, the conditions upon which the planning dimension can be explored statistically are not optimal, and hence care should be taken when interpreting analyses.

Although no standard is provided regarding the minimum requirement, Jarman and Das (1977) commented that a sample of 60 was sufficiently large to perform within-group principal component and common factor analysis. More recently, Carroll (1978) argued that an N of 60 should be considered the bare minimum for establishing reliable results. Consequently the male and female analyses (using samples of 52) should be regarded as exploratory and in need of substantiation using stratified, large samples.

The planning tests

The loadings of the PC and VF varied only slightly from the total group analysis when the female data was considered. Table I shows the intercorrelations between tests. These were submitted to a principal component analysis and the eigenvalues (1.802, 0.982) suggested the extraction of two factors, which were rotated according to a Varimax criterion as there was no significant change in the factor loadings using the oblique solution. This analysis is in Table II, and is similar in structure to Table 6.

TABLE I

Intercorrelations between Planning Tests for the Female, Grade Eight Subjects (N=52)

	PMT	TMT	VS	VF	PC
Porteus Maze Test (PMT)	1.000				
Trail-Making Test (TMT)	-.071	1.000			
Visual Search (VS)	-.102	.500	1.000		
Verbal Fluency (VF)	.043	-.276	-.071	1.000	
Planned Composition (PC)	-.085	.154	.293	-.189	1.000

TABLE II

Principal Component Analysis with Varimax Rotation of Planning Tests for Female, Grade 8 Subjects (N=52)[1]

Variable	Factor I	Factor II	h^2
Porteus Maze Test	-072	939	886
Trail-Making Test	794	026	631
Visual Search	742	-194	588
Verbal Fluency	-539	-247	351
Planned Composition	544	-179	328
Variance	1.772	1.012	2.784
% of Total Variance	35.431	20.242	55.672

[1] Decimals omitted

Intercorrelations between planning tests were computed for the male subjects' results (Table III). Two significant correlations were found: between VF and TMT ($p<0.05$, df=50, one-tailed test) and VF and VS ($p<0.005$, df=50, one-tailed test). The correlation matrix was submitted to principal component analysis. The eigenvalues (1.682, 1.029, 0.998) suggested the extraction of three factors and these were rotated according to a Varimax criterion. Factor I was defined by Trail-Making, Visual Search and Verbal Fluency; Factor II by planned Composition, with minor loadings on Trail-Making and Visual Search; and Factor III by the Porteus Maze Test. (Table IV) These results suggest that there may be two planning dimensions: one defined mainly by essay-writing skills and another involving the TMT, VS and VF.

<u>The simultaneous-successive tests</u>

Table V presents the intercorrelations for the Simultaneous-Successive processing test battery for the female subjects. This matrix was submitted to a principal component analysis, and two factors were extracted with eigenvalues greater than 1.0, and rotated to a Varimax criterion. The factor structure shown in Table VI is similar to Table 9 and the VSTM loading appears to be stable. Table VII gives the intercorrelations between tests for the male subjects and Table VIII, the principal component analysis with Varimax rotation. The VSTM for males correlates more highly with the simultaneous tests than with the successive markers and the factor analysis reflects this change in affiliation. It must be remembered that the analyses by sex are based on 52 subjects only, and as they are basically similar,

TABLE III

Intercorrelations between Planning Tests for the Male, Grade Eight Subjects (N=52)

	PMT	TMT	VS	VF	PC
Porteus Maze Test (PMT)	1.000				
Trail-Making Test (TMT)	-.062	1.000			
Visual Search (VS)	.002	.229	1.000		
Verbal Fluency (VF)	-.029	-.276	-.446	1.000	
Planned Composition (PC)	-.037	.019	.187	-.058	1.000

TABLE IV

Principal Component Analysis with Varimax Rotation of Planning Tests for Male, Grade 8 Subjects (N=52) [1]

Variable	Factor I	II	III	h^2
Porteus Maze Test	013	-055	967	938
Trail-Making	669	-221	-256	562
Visual Search	733	331	075	653
Verbal Fluency	-804	-043	-111	660
Planned Composition	049	945	-056	898
Variance	1.633	1.056	1.021	3.710
% of Total Variance	32.663	21.115	20.420	74.198

[1] Decimals omitted

TABLE V

Intercorrelations between Simultaneous-Successive Marker Tests for Female, Grade 8 Subjects (N=52)

	FC	MFD	ASR	DS	VSTM
Figure Copying (FC)	1.000				
Memory for Designs (MFD)	-.406	1.000			
Auditory Serial Recall (ASR)	.059	-.128	1.000		
Digit Span (DS)	.119	-.171	.499	1.000	
Visual Short-Term Memory (VSTM)	-.078	.130	.288	.222	1.000

TABLE VI

Principal Component Analysis with Varimax Rotation of Simultaneous-Successive Marker Tests for Female, Grade 8 Sample (N=52) [1]

Variable	Factor: Successive	Factor: Simultaneous	h^2
Figure Copying	024	-793	630
Memory for Designs	-077	827	689
Auditory Serial Recall	820	-115	686
Digit Span	776	-228	654
Visual Short-Term Memory	640	344	528
Variance	1.692	1.496	3.188
% of Total Variance	33.835	29.925	63.760

1 Decimals omitted

TABLE VII

Intercorrelations between Simultaneous-Successive Marker Tests for Male, Grade 8 Subjects (N=52)

	FC	MFD	ASR	DS	VSTM
Figure Copying (FC)	1.000				
Memory for Designs (MFD)	-.278	1.000			
Auditory Serial Recall (ASR)	-.032	-.039	1.000		
Digit Span (DS)	-.005	-.017	.686	1.000	
Visual Short-Term Memory (VSTM)	.169	-.209	.196	.120	1.000

TABLE VIII

Principal Component Analysis with Varimax Rotation of Simultaneous-Successive Marker Tests for Male, Grade 8 Subjects (N=52)[1]

	Factor		
Variable	Successive	Simultaneous	h^2
Figure Copying	-106	727	540
Memory for Designs	015	-749	562
Auditory Serial Recall	914	044	837
Digit Span	901	009	811
Visual Short-Term Memory	269	588	418
Variance	1.731	1.438	3.169
% of Total Variance	34.615	28.768	63.383

1 Decimals omitted

the total group analyses should receive primary attention.

The changing affiliations of the VSTM in these analyses of male and female data may be an artifact of the limited sample sizes, even though some inconsistencies have been reported previously (cf. Krywaniuk, 1974; Das, 1972, 1973a, 1973b, 1973c; Jarman, 1975; Leong, 1974; Das and Singha, 1975; Jarman and Das, 1977; Jarman, 1978a, 1978d; Krywaniuk and Das, 1976; Das, Kirby and Jarman, 1975; Molloy, 1973; Das and Molloy, 1975). The most common tendency, other than to load on the successive factor, has been for the VSTM to affiliate with the speed factor. As no test of processing speed (such as Color Naming) was administered in this study, it is difficult to estimate where the VSTM should lie.

The coding and planning tests taken together

Because oblique rotations have not produced more simple factor structures (Table 11), orthogonal rotations were consisered satisfactory for further analysis of the data. Table IX gives the intercorrelations between the simultaneous-successive and planning tests for the female subjects, and these correlations were submitted to principal component analysis. Four factors were suggested by eigenvalues of 2.590, 1.525, 1.158 and 0.980, and they produced a more simple structure. Interpretation of this table should be conservative due to the sample size upon which it was based, however, a number of findings are of some interest.

The Varimax solution is found in Table X, and it shows some variation from the analysis presented in Table 11. Factor I is defined by Figure Copying, Memory for Designs, Verbal Fluency (and an inconsistent

TABLE IX

Intercorrelations of Simultaneous-Successive, and Planning Tests for the Female, Grade 8 Subjects (N=52)

	FC	MFD	ASR	DS	VSTM	PMT	TMT	VS	VF	PC
Figure Copying (FC)	1.000									
Memory for Designs (MFD)	-.406	1.000								
Auditory Serial Recall (ASR)	.059	-.128	1.000							
Digit Span (DS)	.119	-.171	.499	1.000						
Visual Short-Term Memory (VSTM)	-.078	.130	.288	.222	1.000					
Porteus Maze Test (PMT)	.098	-.025	.217	.103	.012	1.000				
Trail-Making Test (TMT)	-.190	.352	-.151	-.170	-.123	-.071	1.000			
Visual Search (VS)	-.212	.205	-.088	-.200	-.187	-.102	.500	1.000		
Verbal Fluency (VF)	.271	-.298	.212	.167	-.035	.043	-.276	-.071	1.000	
Planned Composition (PC)	-.076	.185	-.218	-.119	-.067	-.085	.154	.293	-.189	1.000

TABLE X

Principal Component Analysis with Varimax Rotation of Simultaneous-Successive, and Planning Tests for Female, Grade 8 Subjects (N=52)[1]

Variable	Factor				
	I	II	III	IV	h^2
Figure Copying	678	033	-165	116	502
Memory for Designs - Errors	-744	-033	251	030	619
Auditory Serial Recall	113	831	-029	218	752
Digit Span	171	768	-097	019	628
Visual Short-Term Memory	-415	559	-338	-182	633
Porteus Maze Test	001	101	-082	940	900
Trail-Making Test	-300	-088	727	089	634
Visual Search	-045	-028	881	-061	782
Verbal Fluency	663	274	-027	-055	518
Planned Composition	-131	-163	433	-234	287
Variance	1.777	1.715	1.714	1.048	6.254
% of Total Variance	17.770	17.151	17.144	10.476	62.541

[1] Decimals omitted

loading in Visual Short-Term Memory), suggesting simultaneous processing. This result, suggesting that the famles approached word memory (as presented in the VF tasks) in terms of spatial relations, is supported by intercorrelations of VF and FC and MFD in Table IX. While no additional formal analysis was performed on the VF data, a casual examination of the responses shows many paradigmatic associations, for example, "slow, start, stop", "sailing, ship, sea", "sock, stocking, shoe, sweater", and by using accoustically similar words, for example, "ship, shirt, skirt", "satire, saturn", "shave, shawl, short, shower". These findings support results of Cummins and Das (1978, in press) and Cummins and Mulcahy (1978).

Factor II is defined by loadings on Auditory Serial Recall, Digit Span and Visual Short-Term Memory (a successive factor). Factor III loads highly on Trail-Making, Visual Search with a smaller loading on Planned Composition, while Factor IV uniquely isolates the Porteus Maze Test.

The male, Grade 8 subjects' data produced a slightly different result again. The intercorrelations between tests are presented in Table XI and these were then submitted to a principal component analysis (Table XII). Four factors have eigenvalues greater than 1.0, but a fifth factor (eigenvalue of 0.989) was extracted which produced a more simple solution, accounted for a greater percentage of total variance, but created some problems when identification of factors was attempted.

Factor I suggests the successive dimension, having high loadings on Auditory Serial Recall and Digit Span, but in contrast to Table 21, has a moderate loading on Verbal Fluency. Factor II is defined by Figure Copying, Memory for Desings, Visual Search and also contains a high Verbal Fluency loading. Factor III appears to have a spatial (visualiza-

TABLE XI

Intercorrelations of Simultaneous-Successive, and Planning Tests for the Male, Grade 8 Subjects (N=52)

	FC	MFD	ASR	DS	VSTM	PMT	TMT	VS	VF	PC
Figure Copying (FC)	1.000									
Memory for Designs (MFD)	-.278	1.000								
Auditory Serial Recall (ASR)	-.032	-.039	1.000							
Digit Span (DS)	-.005	-.017	.686	1.000						
Visual Short-Term Memory (VSTM)	.169	-.209	.196	.120	1.000					
Porteus Maze Test (PMT)	.211	-.204	-.129	-.012	.234	1.000				
Trail-Making Test (TMT)	.086	.025	-.004	-.115	-.071	-.062	1.000			
Visual Search (VS)	-.321	.189	-.136	-.135	-.008	.002	.229	1.000		
Verbal Fluency (VF)	.189	-.253	.378	.358	.021	-.029	-.276	-.446	1.000	
Planned Composition (PC)	-.313	-.019	-.062	-.296	-.058	-.037	.019	.187	-.058	1.000

TABLE XII

Principal Component Analysis with Varimax Rotation of Simultaneous-Successive, and Planning Tests for Male, Grade 8 Subjects (N=52)

	Factor[1]					
	I	II	III	IV	V	h^2
Figure Copying	-145	568	257	-511	273	745
Memory for Designs	016	-648	-413	-236	-195	686
Auditory Serial Recall	914	106	008	055	063	854
Digit Span	867	030	048	-228	-105	818
Visual Short-Term Memory	250	-002	760	010	016	641
Proteus Maze Test	-191	032	745	-116	-121	621
Trail-Making Test	-022	-119	-102	-024	929	889
Visual Search	-060	-717	148	259	279	685
Verbal Fluency	423	678	-100	056	-284	732
Planned Composition	-151	-020	-034	900	018	835
Variance	1.913	1.746	1.416	1.266	1.164	7.504
% of Total Variance	19.130	17.456	14.156	12.659	11.640	75.041

[1] Decimals omitted

tion) loading highly on the Porteus Maze Test, Visual Short-Term Memory and Memory for Designs. Factor IV is defined by the Planned Composition and Figure Copying, and Factor V sets the Trail-Making test in a unique position. These diversified factor loadings of the male subjects might suggest their widely differing ways of approaching various tasks in that some individuals use one coding process more often than others.